The UNESCO Courier

A window open on the world

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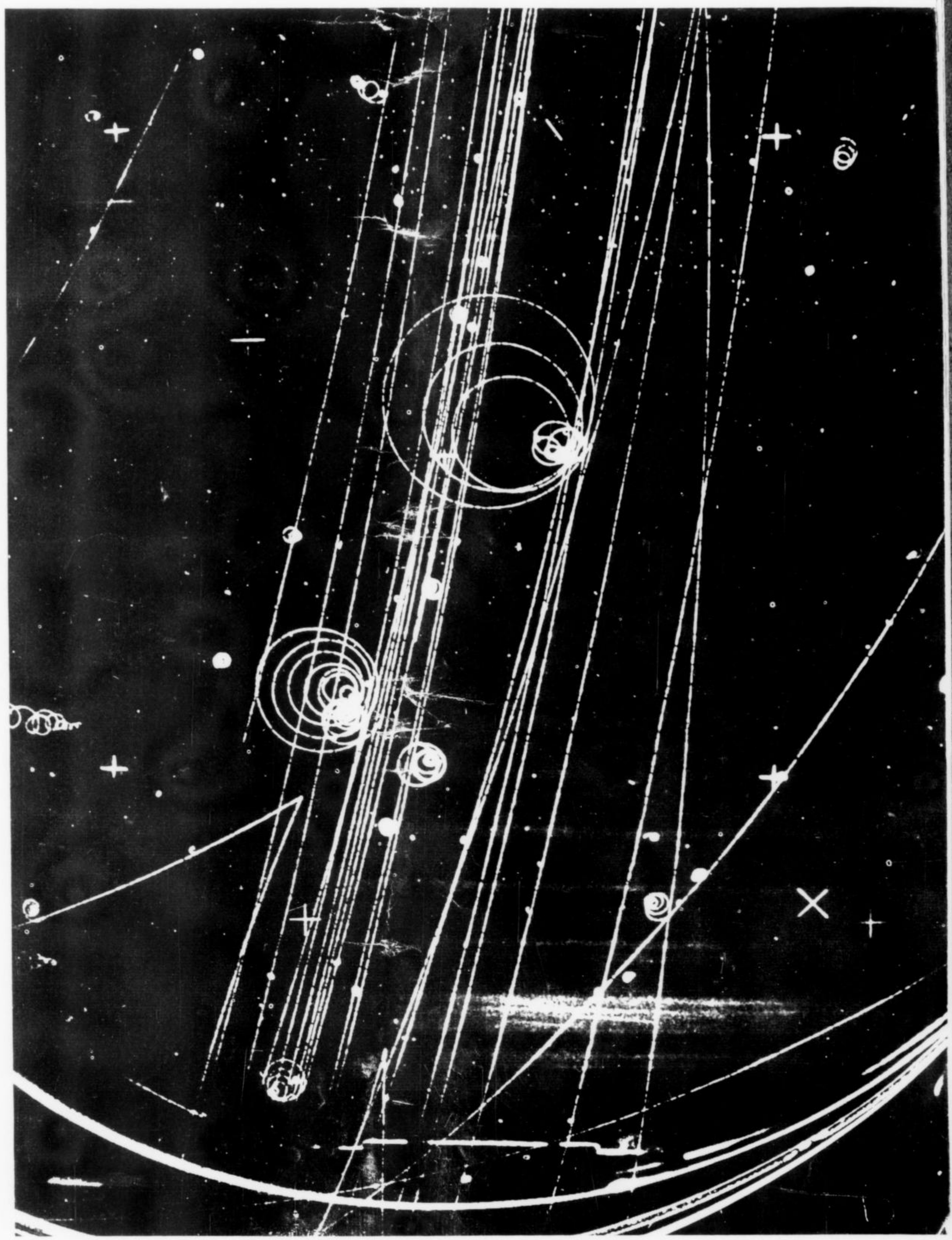
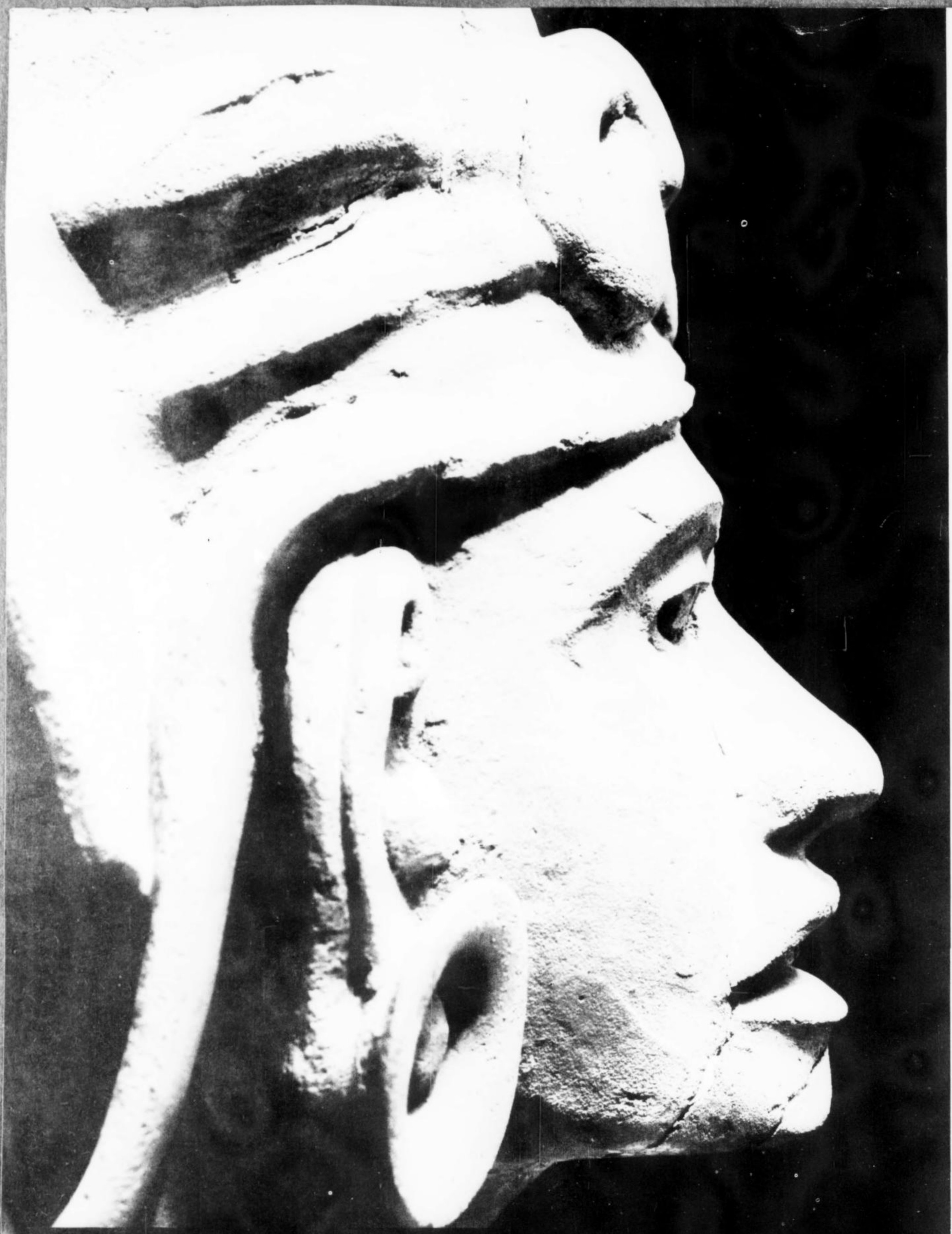


PEACEFUL USES OF THE ATOM



TREASURES OF WORLD ART 27

Profile of Chalchiuhcihuatl

Sculptured head of Chalchiuhcihuatl, goddess of sustenance and fertility of the Totonacs, one of the ancient peoples of Mexico, whose civilization flowered from the 7th to the 14th century A.D., before its subjugation by the Aztecs. The Totonacs were master builders and architects, as shown by the buildings they raised at Tajan, their cultural centre, and notably the city's mighty temple pyramid. Accomplished sculptors, they produced ceramic and terracotta works of admirable design and finish.

K. Stavenhagen Collection, Mexico - Photo r. Bulloz, Paris

The UNESCO Courier

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Special notice

As announced last month, this issue is dated July-August and contains an additional 16 pages, to permit the UNESCO COURIER to re-establish its normal production schedule, disrupted by the printers' strike in France in May and June. A further 16 pages will be added to another issue before the end of the year, so that subscribers will receive the normal complement of pages usually foreseen during the year.
Our regular annual double number, usually dated August-September, will be published next month, dated exceptionally September-October. It will contain 68 pages plus eight pages in full colour.

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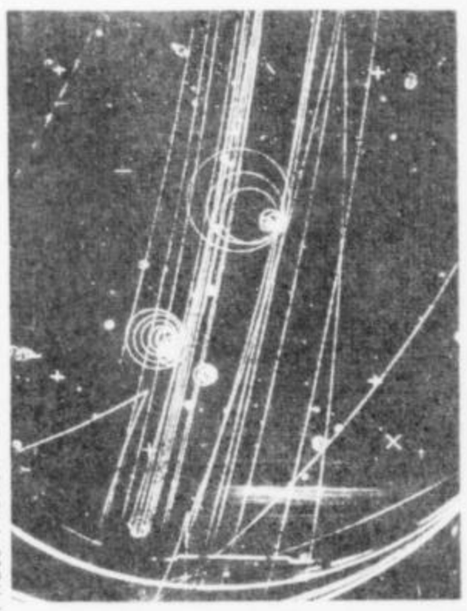


Photo French Commissariat of Atomic Energy-Paris.

Cover photo

These filigree-like tracings are the marks of incredibly short-lived particles detached from an atomic nuleus and photographed in what is called a "bubble chamber" (see page 40). A single experiment often requires the study of 600,000 to 800,000 such photographic negatives. It is hoped that this tedious job may soon be replaced by direct computer analysis of nuclear decay.

The International Atomic Energy Agency

THE TAMING OF THE... ATOM FOR PEACE

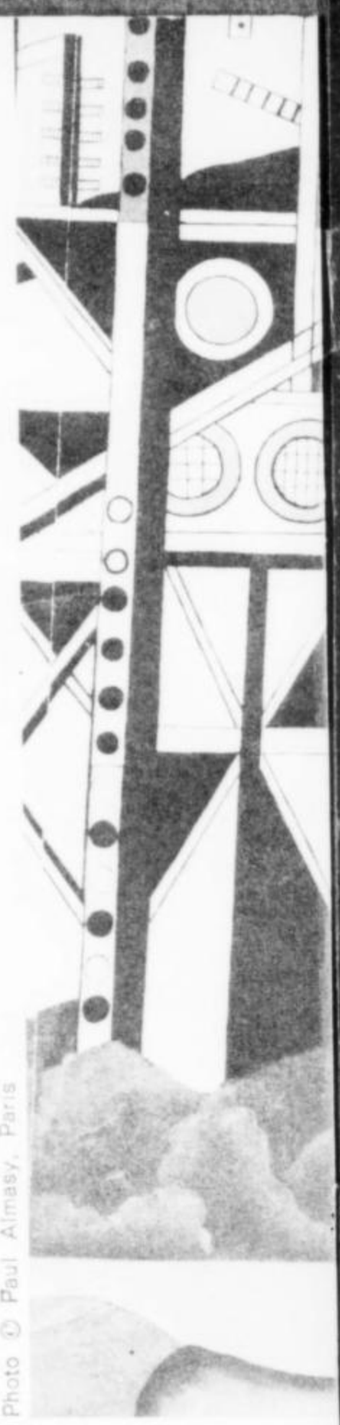


Photo © Paul Almasy, Paris

Fernand Léger, the famous French painter executed the painting shown here (measuring a giant 8 metres by 5 metres) for the Paris science museum, Palais de la Découverte. It represents man's harnessing of energy for peaceful purposes.

THROUGHOUT a world beset by growing problems of over-population, lack of food and limited traditional resources, nuclear energy is emerging as a most powerful force for the benefit of man.

World leaders and scientists of vision realized this well over a decade ago. Due to their foresight, the International Atomic Energy Agency of the United Nations was founded to find ways of harnessing atoms for peace and preventing their use for war.

After the World War Two bombings of Hiroshima and Nagasaki had shown the terrible destructiveness of atomic power, the world was desperately anxious to turn over the nuclear coin and investigate its beneficial side. However, until 1953, no acceptable formula could be found to establish the tool for these investigations.

Then President Eisenhower of the United States urged the establishment of an international organization through which the technically developed countries "would dedicate some of their strength to serving the needs rather than the fears of mankind."

This proposal marked the turning point in the postwar evolution of nuclear energy from its military applications to its peaceful applications for the benefit of everyone.

In 1954, the United Nations General Assembly unanimously adopted an "Atoms for Peace" resolution expressing the hope that the International Atomic Energy Agency (IAEA) be established without delay. In October, 1956, the Statute was approved unanimously at a conference of 81 nations: on July 29, 1957, the Agency officially came into being. Today it has 98 member states.

The IAEA was conceived with two broad aims: to actively promote the peaceful uses of nuclear energy, and to ensure that these applications are carried out without risk to world peace and to world health. These are still vital considerations, but since the agency's beginnings in 1957, its scientists have widened their scope of activities to include other related areas affecting practically every walk of life.

By 1958, scientists were already hard at work in their first laboratory in Vienna; the first symposia were organized; experts were appointed for technical assistance; and the first fellowships for research were awarded.

It was immediately recognized that one of the main factors to encourage wider use of nuclear energy is the spreading of scientific and technical know-how. Accordingly, the first major enterprise was the fellowships programme.

Over 3,000 fellowships have been awarded to date. In addition, a thousand persons have been trained in Agency-organized courses and 120 visiting professorships provided. Something like 15,000 scientists have met at 100 conferences and symposia to discuss 5,500 scientific papers. Furthermore, nearly 200 panels, 40 study groups and 13 other meetings were convened.

Knowledge of the properties of stable isotopes and radioisotopes has led to great advances in research and technology.

Isotopes and instruments associated with them can be turned to useful purposes easily, often cheaply and with relatively quick and practical results, many of them particularly valuable to developing countries. Here are some of the ways that they are being used by the IAEA and other organizations with which it collaborates:

■ **In Agriculture:** Improvements of yields through collective research efforts to make better use of fertilizers, as for rice, studied in 12 countries, and for maize in eight countries; production of better rice, wheat and barley through radiation-induced mutations; control or eradication of insect pests; protection of food against contamination; preservation of stored food by irradiation; studies designed to make fullest use of water in the soil;

preparation by radiation of vaccines for animals.

■ **In Hydrology:** For six years a continuing world survey of the content of tritium (the radioactive isotope of hydrogen) as well as some stable isotopes has been carried out jointly with the World Meteorological Organization to determine the water turn-over on earth; more than 20 countries have been helped to estimate their local water development problems; studies of 20 large rivers in various parts of the world were carried out jointly with Unesco as part of the programme of the International Hydrological Decade now in progress, with which the tritium survey is also linked.

■ **In Medicine:** Goitre research ranged from the heights of the Andes in Peru to those of the Himalayas in Nepal; arrangements were made for the provision of equipment for radiological treatment of cancer in seven countries. Radioisotope techniques and charts for medical diagnosis and treatment have been developed and standardized. The highest priority has been given to four groups of subjects — anaemia, endemic goitre, malnutrition and the effects of parasitic infections on human beings — and research has been promoted in 44 countries ; a training programme provides the majority of qualified personnel working in nuclear medicine in developing countries.

A programme aimed at making snakebite serum generally available as a result of radiation treatment of venom has been initiated in the hope of saving many of the 3,000 lives lost annually. Sterilization of tissues and hospital equipment is being developed to facilitate surgical work and reduce dangers of infection.

■ **In Industry:** Increasing efforts have been made to acquaint nations with radioisotope techniques for improving the quality of production of manufactured goods; process, wear and tear and flow control; sterilization of medical products, all ways of saving hundreds of millions of dollars a year as well as leading to more rapid industrial development.

Nuclear energy's greatest contribution to human welfare will probably be power production. At present, the Agency acts mainly as an international adviser. Its experts counsel individual countries and regions on the feasibility of their nuclear power proposals, provide information enabling a choice to be made, help in choosing sites, make cost evaluations and give guidance for safe operation.

These services are especially important for countries whose size or present state of development preclude them from taking on these tasks alone.

Another, increasingly important application of nuclear energy is in the large-scale desalting of sea water. Glenn T Seaborg, chairman of the U.S. Atomic Energy Commission, underlined its importance when he said, "I know of no more exciting prospect for the future—a future which I believe is not distant—than that of nuclear reactors producing unprecedented amounts of energy for the production of electric power and the desalting of water in some of the earth's most arid regions."

Since 1963, the IAEA has served as a clearing house for the international exchange of information on nuclear desalting as well as bringing together technical experts and policy-makers from all parts of the world during eight meetings of its Panel on Nuclear Desalting. Now it is adding to this work the exciting idea of linking the nuclear power/desalting operations with chemical and fertilizer plants to create new agro-industrial centres.

The Agency has also sponsored a tripartite study into the possibility of a huge dual-purpose nuclear power and desalting plant to serve the arid regions of Mexico and the United States surrounding the Gulf of California. If it proves feasible, it might produce as much as one thousand million gallons of water a day.

The IAEA is acting as an observer for a similar project between Israel and the U.S.A., and power and desalin-

CONTINUED ON NEXT PAGE

Electric power and desalted water for the earth's arid regions

ation missions have been sent to Chile, El Salvador, Finland, Republic of Korea, Pakistan, Peru, the Philippines, Thailand, Tunisia and Turkey.

Apart from nuclear power and desalting, the Agency is helping to advance reactor technology through the direct support of research on a regional or international basis.

The IAEA's scientists recognized that applied and basic science are indivisible and have planned their programme accordingly. The first provisional laboratory, set up in 1958, dealt with physics and some chemistry involving low radioactivity. It is still maintained although its role has changed: today it is used partly for investigations into radiation accidentally or medically introduced into the human body.

SINCE 1961, a functional laboratory has been in operation at Seibersdorf, about 20 miles south-east of Vienna. It has sections for nuclear and medical physics, chemistry, agricultural research, hydrology and electronics. Among the wide range of subjects dealt with have been foodstuffs, the age and content of meteorites, and the quality of ores and sedimentation in rivers. Furthermore, 8,000 of its radioisotope standards serve to calibrate instruments and check research work in 56 countries.

Also created in 1961 was the International Marine Radioactivity Laboratory at Monaco. It studies the effects and dispersal of radioactivity in the sea, its living creatures and its plants. Its work will give guidance on the future disposal of radioactive waste from the growing number of nuclear installations, including ships.

The best example of the IAEA's contribution to basic research is its International Centre for Theoretical Physics in Trieste, inaugurated in 1964 and headed by one of the world's most brilliant physicists, Professor Abdus Salam of Pakistan. Its main value has been to encourage scientific thinkers, especially from developing countries, who previously found it difficult to maintain contacts and standards of work.

Over 400 special reports have been produced; 600 p[l]cists from 53 countries have part[i]pated in the work; seminars, training courses and research groups have resulted in useful publications; scientists from developing countries are drawn to the Centre by a system of associate membership, fellowships, senior and junior physicists positions, and a scheme of affiliations with other institutions. A symposium on contemporary physics which has just ended was one of the most important events in theoretical physics for many years. Nine Nobel Laureates were among 250 leading scientists of many disciplines who took part.

The IAEA's basic research programme also promotes the effective use of research reactors in developing countries by providing experts to advise on their efficient utilization.

As the value of nuclear power is accepted by more countries, the need for health and safety measures is increased. The Agency has evolved basic safety standards for radiation protection and regulations for the safe transport of radioactive materials.

These rules are mandatory for all activities with which the IAEA is connected and, although it does not have the power to impose them on nations, there is a growing trend to adopt these or similar health and safety standards.

To ensure that IAEA assistance is not diverted for military purposes and to apply safeguards at the request of the parties to any bilateral or multilateral nuclear agreement, a system of safeguards procedure has been established which applies to reactors and to installations where used nuclear fuel is reprocessed. The system will be extended to plants for conversion and fabrication of nuclear fuel. It now covers the entire fuel cycle except isotope separation plants.

The first country to accept the safeguards was Japan, which in 1959 obtained three tons of fuel through the Agency's intermediary. Twenty-eight other countries have since accepted Agency safeguards, some of which are supplied with their nuclear materials by the Agency.

The number of installations now subject to control is 120, including 70 reactors. Often these installations represent the sole or major nuclear activity in the country concerned.

Under the system, Member States maintain records of the materials under safeguards and report periodically. An important element is on-site inspections by a team of inspectors with broad powers of access and investigation.

Photo IAEA

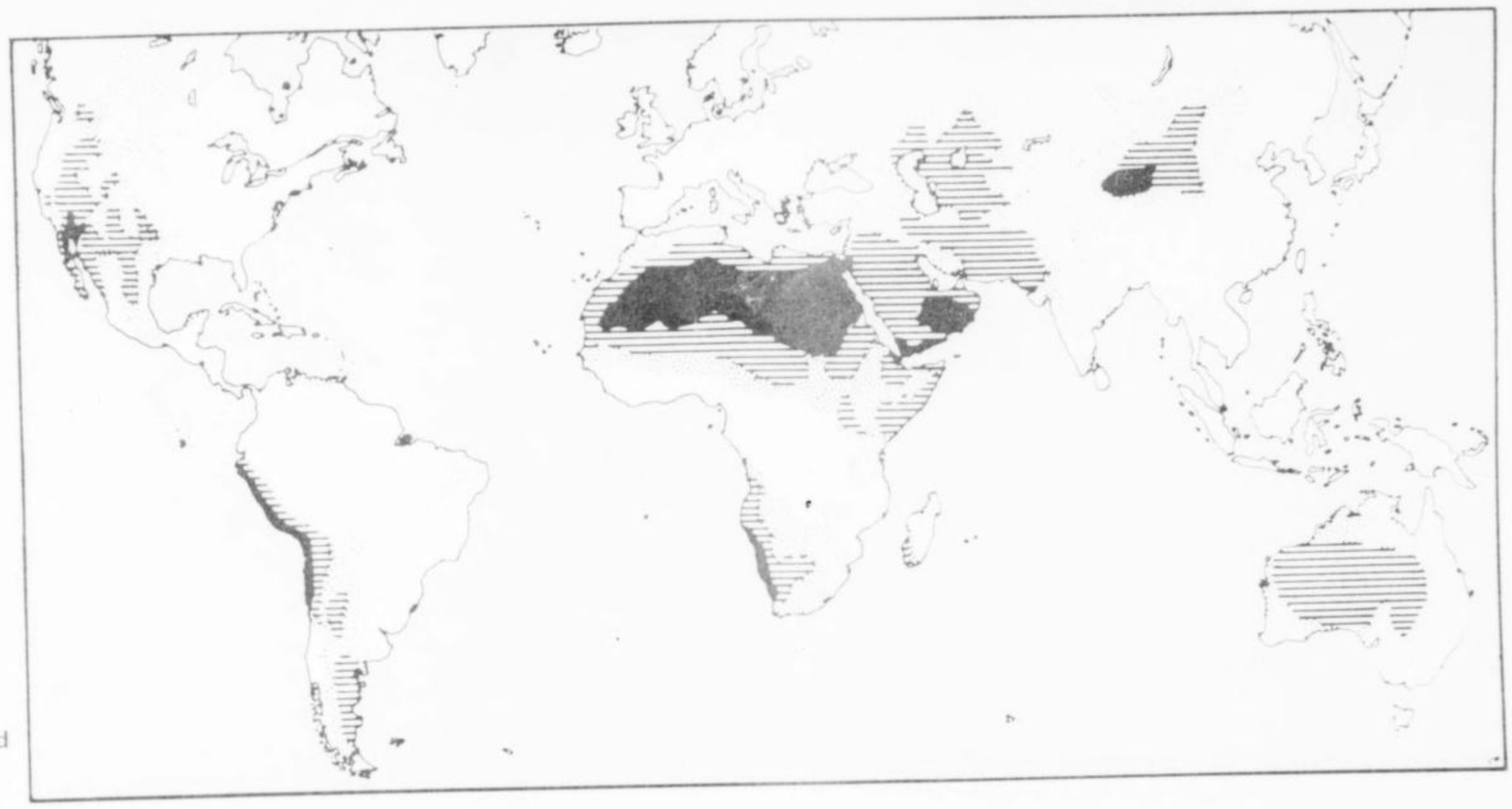
ATOMIC RICE. The International Atomic Energy Agency (IAEA) has set up a plant mutation laboratory at Seibersdorf, Austria, where scientists have successfully used radiation to produce better varieties of rice, with higher yields, quicker maturity and greater resistance to disease. Seeds from many rice-growing countries are irradiated and grown in paddies under plastic tents on an experimental basis. Here, an IAEA fellowship holder, Mr W.C. Li, from the Republic of China, studies a new rice strain produced by radiation.

As this team gains more experience, it is called upon to fulfill more tasks. The Treaty for the Prohibition of Nuclear Weapons in Latin America, the so-called Tlatelolco Treaty, signed by 21 nations in 1967, nominates the Agency to apply its safeguards to the nuclear activities of the contracting nations.

However, a danger remains. Nations are still free to manufacture nuclear weapons if they desire. And if more countries decide to do so, the present trend to non-proliferation could be broken with possible disastrous results.

The Non-Proliferation Treaty, sponsored by U.S.S.R. and U.S.A. and adopted in June 1968 by the U.N. General Assembly with a very considerable majority, opens more optimistic perspectives for ensuring greater safety for the world. Non-nuclear weapons states, which are parties to the treaty, accept not to produce atomic bombs. It is foreseen that the IAEA will carry out the international control, ensuring that the treaty is followed.

The treaty was signed by the U.S., Soviet Union and U.K. (three of the



NUCLEAR THIRST QUENCHER. The desalting of seawater by nuclear energy holds out untold promise for the world's agriculture of tomorrow. Deserts reach down to the sea along some 18,000 miles of the world's coastlines. Installation of water desalting nuclear plants would transform thousands of acres of parched soil and permit the setting up of agro-industrial complexes. Cheap electricity from nuclear power plants could also make inland deserts bloom with water pumped from deep underground natural reserves. The critical problems of certain arid areas, where no rain may fall from one year to the next, are underlined by the fact that 37 gallons of water are needed to make one slice of bread and 3,750 gallons to produce one pound of beef.

world's five nuclear powers) and 53 other nations in Washington, Moscow and London on July 1, 1968, and other signatures brought the total to 64 by July 4. A total of 40 nations plus the three signatory nuclear nations must ratify the treaty before it becomes international law.

An essential aspect of the IAEA's approach to both its task and its success to date is international co-operation. We have already indicated projects involving different countries. There are others.

One, the NPY agreement with Norway, Poland and Yugoslavia, is aimed at improving knowledge of reactor physics, using experimental facilities in all three countries. Another joint programme of research in reactor physics uses the NORA reactor in Norway. It has provided useful data for the development of power reactors and has given experience to scientists from many nations.

In South-East Asia, a regional training and research programme, using a neutron crystal spectrometer, was established in 1965 at the Philippine Atomic Research Centre, Quezon City, administered by the Philippines, India and the IAEA. India built the spectrometer and provided scientists and technicians. Indonesia, Korea, Republic of China and, of course, the Philippines, whose research reactor is also used, have been taking part.

The Middle Eastern Regional Radioisotope Centre for the Arab countries, set up under Agency auspices in Cairo in 1963, trains specialists for work and research. Participants come from Algeria, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, United Arab Republic and Yeman, and have included trainees from Nigeria and Ghana.

THE IAEA also co-operates with the United Nations and some of its specialized agencies such as the Food and Agricultural Organization, the World Health Organization, Unesco, the World Meteorological Organization, the International Labour Organization, and the United Nations Development Programme (UNDP).

In fact, the Agency was the executing body of some of these joint IAEA-UNDP projects. One of these showed the value of nuclear power in the Philippines; in India the use of atomic energy will be intensified to increase agricultural production; in Central America, the campaign against the Mediterranean fruit-fly is being carried out, and in Yugoslavia, valuable work to assist agriculture and animal husbandry has been accomplished.

In all its work, the Agency has taken as guiding principle the urgent need to help improve standards of living in developing countries. A review made in 1967 showed that 30 per cent of the money spent goes directly to projects for this purpose, and that a large proportion of the remainder is spent on activities of interest to such nations. As techniques develop, the trend is to concentrate increasingly on practical rather than advisory tasks.

These widespread and diverse activities, in co-operation with nations and organizations throughout the world, illustrate how the International Atomic Energy Agency, born out of a realization that the promise and problems of the peaceful uses of nuclear energy recognize no national boundaries, has moved steadily towards the great objectives for which it came into existence.

CHARTING THE NUCLEAR LABYRINTH

A basic survey of the atom
and its peaceful uses

by I. H. Usmani

NEVER in the annals of history has a scientific discovery so profoundly affected the course of human destiny as the discovery of atomic energy. Its potential for destruction is enormous and its use for economic development unlimited. It is this co-existence of fear of annihilation and hope for the progress of human welfare through its application that has ushered us into the present era rightly known as the "Atomic Age."

Let us see what an atom is and how it becomes such an enormous source of energy and a tool to solve problems of development in the fields of industry, agriculture and medicine.

All the tangible things that we see around us, whether in the form of solids (like paper, pen or pencil), liquids (like water), or gases (like air), are all combinations of certain basic materials or substances called "Elements" of which only 92 are found in nature: copper, iron, gold, uranium, hydrogen and oxygen, etc.

Each of these elements has certain specific physical and chemical properties or characteristics by which it is identified. The last indivisible particle of an element is called the "Atom." Thus, we have an atom of iron, an atom of gold and an atom of hydrogen, each having characteristics typically its own.

If these elements are arranged in order of their weights in a tabular form, Hydrogen, being the lightest, occupies position number one and Uranium, being the heaviest, occupies position no. 92. All others fall in between these positions.

Atomic Structure

To give an idea of the size and weight of an atom of hydrogen, nearly 36 billion atoms can be accommodated on a pin-head and one million million atoms weigh only one millionth part of a millionth of a gramme!

All atoms have internal structures which are built out of a combination of only three fundamental "bricks" called the "Electron," the "Proton," and the "Neutron." The last two have more or less the same weight and size but the electron is about 1,800 times lighter in weight. Further, the electron is electrically negative, carrying the smallest possible electric charge, while the proton carries a positive charge equal to the negative charge of the electron. The neutron carries no charge and is electrically neutral, hence its name.

Finally, the structures of all atoms are built in such a way that in the centre there is an inner core or a "Nucleus" which consists of protons and neutrons held together by a very strong binding nuclear force. Around

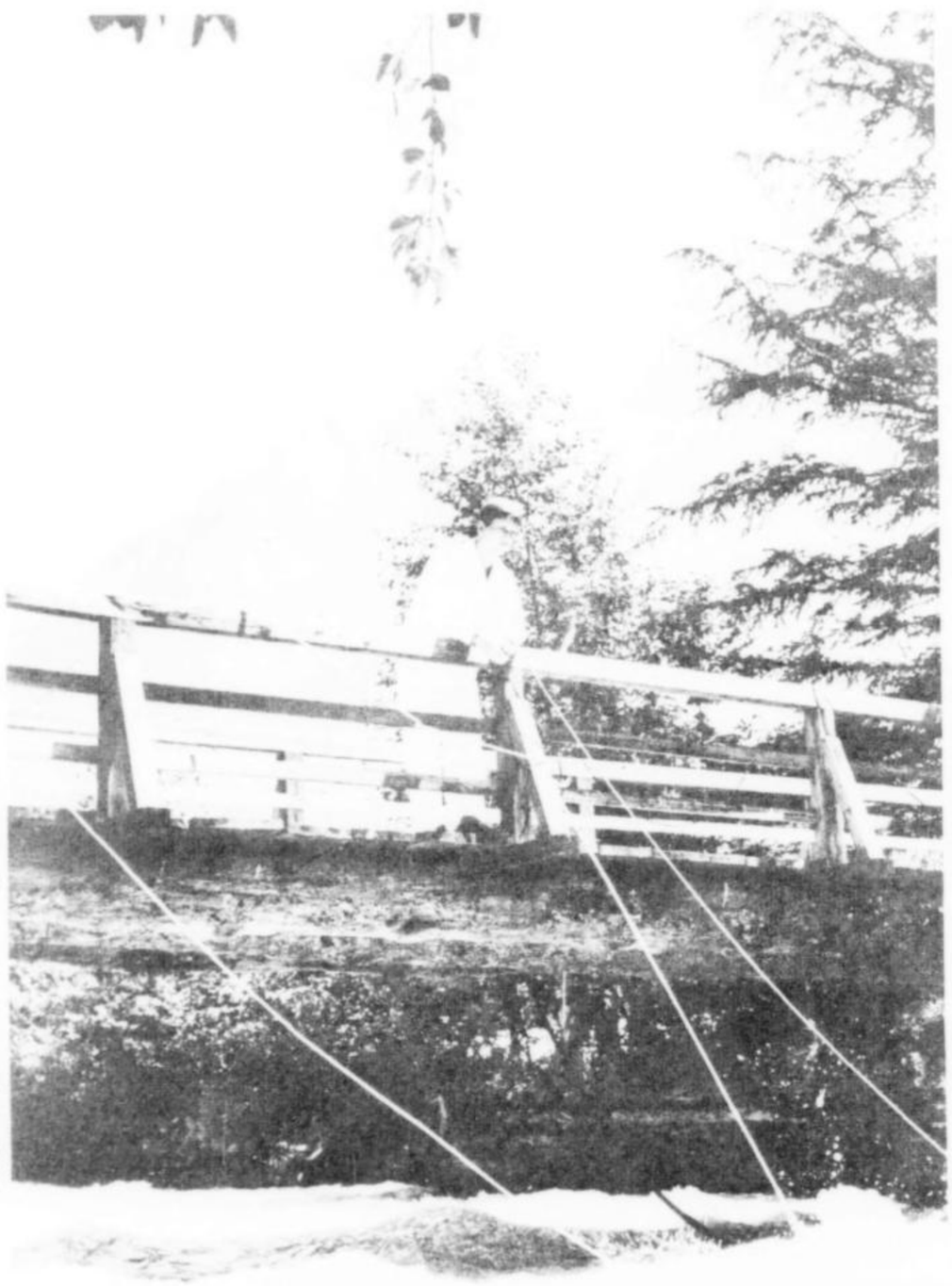


Photo French Atomic Energy Commissariat

ATOMIC ANGLER. The patient angler (left) is not what he appears to be. He is actually measuring the flow of water in the River Arve, near Chamonix (France) in preparation for a local hydro-electric project. His sounding lines are linked to Geiger counters which record radioactivity brought down by the water from a radioisotope half a mile upstream. Only a minute, harmless amount of tracer is needed to measure the quantity of water flowing in the river.

DR. I. H. USMANI *of Pakistan, one of Asia's foremost nuclear physicists, is Chairman of the Pakistan Atomic Energy Agency. He was responsible for establishing the Pakistan Institute of Nuclear Science, the Atomic Energy Centres of Lahore and Dacca, an Atomic Energy Agricultural Research Centre in Tandojam and five Atomic Energy Medical Centres in Pakistan. He commissioned and supervised Pakistan's first atomic reactor in 1965 and was responsible for launching Pakistan's first space rocket in 1962.*

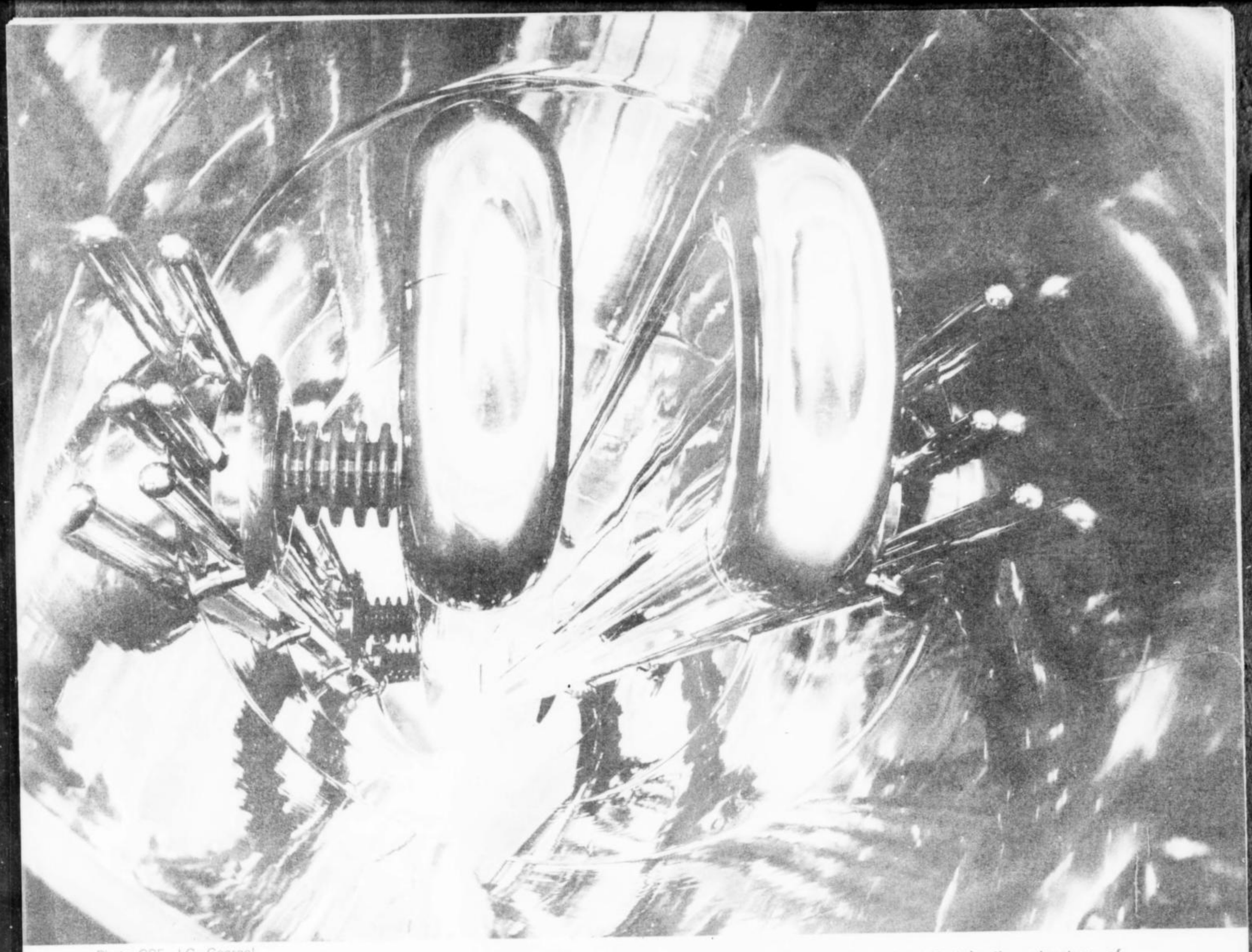


Photo: CSF - J.C. Georgel

Paradoxically, the deeper the nuclear scientist probes the infinitely tiny structure of sub-atomic matter, the larger and more powerful are the tools he needs, notably giant particle accelerators such as the cosmotron and synchrotron. Shot at fantastic speeds from these machines, atomic particles pass into a "sorting" apparatus, such as the particle separator shown above, and are then detected visually and studied by physicists.

the nucleus, the electrons revolve in orbits just as the planets revolve around the sun in our solar system.

Isotopes

Based on the above theory of atomic structure, it has been found that it is the number of protons in the nucleus (and, therefore, the number of electrons in the orbits) that determine the chemical properties of an element. The presence or addition of neutrons in the body of the nucleus does not cause any change in these properties.

Thus, it is possible to have two atoms of the same element having the same number of protons in the nucleus but a different number of neutrons. Both will have identical chemical properties but the nucleus of one will be heavier than the other. These are known as two "Isotopes" of the same element ("Iso" in Greek means "same" and "tope" means "place"). Thus, all elements have isotopes which are chemically indistinguishable from one another but which are physically different in weight because of the presence of a different number of neutrons in their nuclei.

Radioactivity

Building up the structures of atomic nuclei by adding protons and neutrons, as we go along from hydrogen, the lightest, to uranium, the heaviest, we find that a stage comes when the piling of protons and neutrons causes instability and the nucleus begins to disintegrate by emitting the extra protons and neutrons or combinations thereof. This emission of radiations in the form of particles or rays is known as "Radioactivity."

When the unstable nuclei of radioactive elements disintegrate, they emit three kinds of "radiations" called "Alpha" particles, "Beta" particles and "Gamma" rays. The alpha particles are nothing but a combination of two protons and two neutrons (helium nucleus without the orbiting electrons) carrying a positive charge due to the two protons. The beta particles are just negatively charged electrons moving at high velocities and gamma rays are deep penetrating radiations.

All the disintegrating nuclei "decay" till such time as they revert to the most stable nuclear structure. Time taken to decay to half the original number of atoms of a given kind is referred to by the scientists as the "Half Life" of a radioactive atom or "Radioisotope" for short.

Transmutation of Elements

According to the theory of atomic structure outlined above, if one element differs from another element by just the number of protons and neutrons in the body of the nucleus, it follows that if somehow these numbers

CONTINUED ON NEXT PAGE

Photo © APN

NUCLEAR ENERGY IN THE POLAR REGIONS

The polar regions may not seem a likely place to find atomic power plants, yet at least two are now in operation in these frozen regions. Above left, the Soviet icebreaker "Lenin" operates regularly in the Arctic ice equipped with a nuclear reactor. Below, nuclear reactor, supplying heat, power and electric light at the U.S. scientific research station at McMurdo Sound, Antarctica. Small reactor unloaded there in 1961 is shown in photo left. A Soviet Antarctic research station is seen reflected upside down on a heliograph (meteorological measuring instrument) in striking photo, right. A dozen countries have been working together in the Antarctic "Land of Science" since 1957. Radioisotope measurements have revealed that the oldest Antarctic rock is some 3,500 millions years of age.

Photos Martin Company

could be changed by adding or removing protons and neutrons to or from the nucleus of an element, it could be changed into another element. That this is possible was first demonstrated by Lord Rutherford in 1919.

Fission

The German scientists Otto Hahn and Fritz Strassmann in 1938 found that, when slow neutrons hit the nucleus of the radioisotope uranium-235, the nucleus fissioned into two almost equal halves and there was a tremendous burst of energy! How was this to be explained?

As early as 1905, Einstein had proved that matter and energy are interconvertible and that if somehow matter could be destroyed, it would appear in the form of energy and this interconvertibility would be governed by a very simple equation $E = Mc2$ where E is the energy liberated, M is the mass converted and c is the constant velocity of light which is 186,000 miles or 300,000 kilometres per second.

Einstein's equation satisfactorily explained the phenomenon of fission observed in the experiments of Hahn and Strassmann. This led to calculations which showed that if one pound of uranium-235 could be fissioned it would liberate as much energy as 1,400 tons of high grade coal.

Reactors

The fission of every atom of uranium-235 results in the liberation of energy as well as the release of two to three secondary neutrons from the disintegrating nucleus. These neutrons if slowed down by a "moderator," like graphite or water, could get absorbed by another atom of uranium-235 present in a piece of uranium and cause another fission which in turn would release energy and two to three more neutrons and so on.

Thus, a chain reaction can be set up

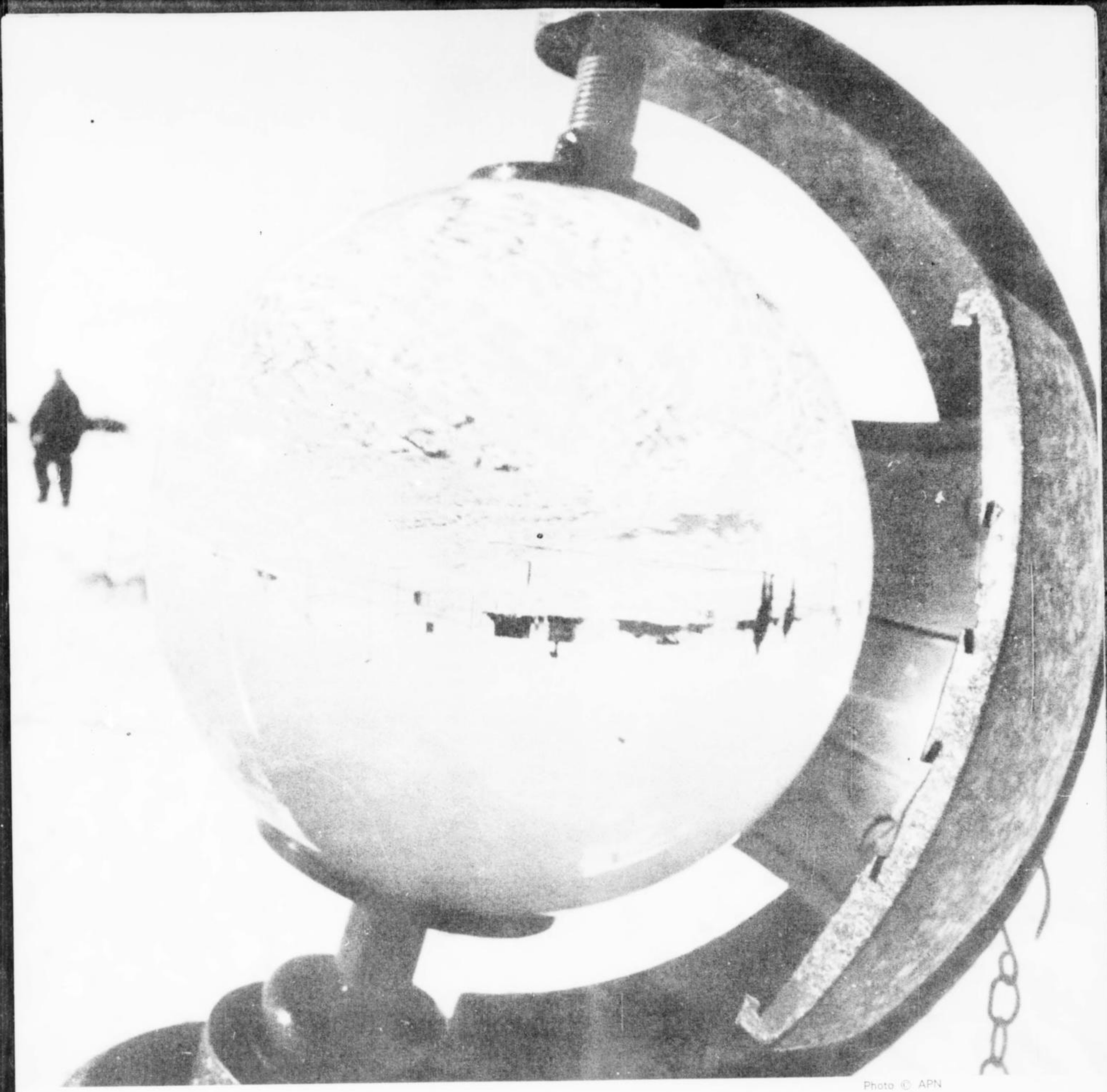


Photo © APN

and liberation of energy can be controlled by adjusting the absorption of secondary neutrons by inserting some material like boron or cadmium. A contrivance sustaining a controlled chain reaction is called a "Reactor".

Nuclear Power

Liberation of atomic energy once controlled in a reactor can be used to heat water which can produce steam which in turn can drive a turbine to generate electricity for supply to a town. Thus, a nuclear power reactor can replace a coal, oil or gas-fired boiler of a conventional thermal power plant.

The scale of energy produced from the conventional fuels and uranium is, however, vastly different. The burning of one pound of coal generates 3.5 units (Kwh) and one pound of oil 5.5 units (Kwh) of energy; the fissioning of one pound of uranium liberates 10.5 million units (Kwh) of energy! It is this enormous difference in the output of energy that has propelled the development of modern nuclear power reactors to a degree that has made them the cheapest source of power generation.

Today, it is possible to generate a million KW (1000 MW) from a single nuclear reactor producing power at only about one quarter of a cent (US) per unit (Kwh). Such a cheap and abundant supply of electric power has made conversion of sea water into fresh water on a large scale for domestic and industrial purposes a distinct economic possibility. In future, it might be possible to establish big energy centres on sea coasts with agro-industrial complexes producing power, water and fertilizers (from sea salts), thus creating a thudding impact on economic development.

In countries where the resources of fossil fuels (coal, oil and gas) are limited and where power is needed, not at a "competitive cost" but at "any cost," to accelerate the pace of economic development, as in countries of Asia, Africa, and Latin America, nuclear power is a boon.

CONTINUED ON NEXT PAGE

Strawberries and oranges that stay fresh

Even in highly industrialized countries of Europe, in the U.S.S.R., Canada and U.S.A. where cheap and abundant supply of coal is available, nuclear power stations are replacing the conventional thermal stations because the uranium fuel is so compact that a comparatively small quantity can easily be transported to feed a big nuclear power station in the heart of the load centre resulting in saving on transport of fuel and long distance power transmission lines (see article page 17).

Breeder Reactors

Natural uranium contains 99.3 per cent of the isotope uranium-238 and 0.7 per cent of the isotope uranium-235. When a slow neutron hits atoms of uranium-235 in a reactor, fission takes place and we get energy which is converted into electric power. But when the neutrons hit the nucleus of uranium-238, which is present in the reactor fuel in abundance, transmutation takes place converting uranium-238 into a new element, neptunium, which, after the emission of a beta-particle, decays into a very long-lived element called plutonium, having an atomic weight of 239 and atomic number 94.

Like uranium-235, plutonium-239 is fissionable. In other words, while uranium-235 fissions and gets consumed, the uranium-238 breeds into plutonium-239 which on recovery from the spent-fuel as a byproduct, can either be recycled back into the reactor or used as fuel in fast "Breeder Reactors", using fast neutrons without a moderator. It is hoped that the technology of such reactors will be perfected within the next 10-15 years which would bring a power revolution in its wake.

Production of Radioisotopes

Because a reactor is a big source of neutrons released from the fission of uranium, it is employed to produce a large number of radioisotopes of different elements either by the transmutation or the activation process.

For example, if sulphur is inserted in the reactor, the neutrons convert it into radioactive phosphorus with a half life of 14.5 days and if tellurium is inserted, it gets converted into radioactive iodine with a half life of 8 days.

Similarly, ordinary cobalt, when hit by neutrons, is activated into radioactive cobalt with a half life of nearly 5 years. These "artificially" produced radioisotopes have been used in a variety of ways to solve problems in the fields of agriculture, hydrology, medicine and industry. In fact, the limit to which they can be used, is the limit of man's imagination and genius.

Uses of Radioisotopes as Tracers

The principle underlying the use of radioisotopes is that the radiations emitted by them can be detected by sensitive electronic instruments and can also be recorded on a photographic plate, so that even where they are present in minute quantities of say one in a million, they can be "traced."

■ **Agriculture.** One of the important applications of tracer technique in the field of agriculture is the determination of the uptake of fertilizers by a plant from the soil. Labelled phosphate fertilizer is mixed in the soil and the uptake by the plant from different types of soil is studied from the radiographs. Similarly, if "labelled" fertilizers are applied at different stages of the growth of a rice or wheat plant (seedling stage, flowering stage, etc.), the radiographs can help to determine the right stage when the fertilizer should be applied for maximum yields.

■ **Medicine.** Certain organs of the body have great affinity for specific elements which are absorbed from the intake of foods. For example, iodine is absorbed entirely by the thyroid gland, iron plays a vital role in the blood-stream and cobalt helps the synthesis of vitamin B in the liver.

Thus, when radioiodine dissolved in water is administered to a patient and a "scanner" is placed against his throat, the emission of electrons from radioiodine are recorded on the photographic paper in the scanner giving an idea of the functioning of the thyroid gland.

Labelled pharmaceuticals and radiomedicines are being increasingly used in the diagnosis and treatment of diseases, so much so that nearly 80 per cent of the total production of isotopes and their uses today, is in the field of medicine and public health.

■ **Hydrology.** The injection of radioisotopes which can mix with water, like bromine, iodine and tritium, has helped to "trace" the movement of sub-soil streams and to discover underground reservoirs of water for pump irrigation. Similarly, the directional flow and volume of seepage water from the beds of irrigation canals can help in the study of the problems of water balance in the waterlogged areas.

One very successful application of tracers has been in the use of labelled sea-sand, to determine the movement of silt in harbours. Such studies carried out have not only helped in the dredging of the silt but in dumping it at an appropriate spot so that it is not brought back into the harbours by the undercurrents. The London Port Authority seems to have cut down its dredging budget by at least 50 per cent as a result of the studies carried out with the help of labelled sand.

Uses of Radioisotopes as Radiation Sources

Although the application of radioisotopes as tracers is important, their use as sources of radiations is equally significant. The radiations most widely used are the gamma rays from radioactive-cobalt activated in a reactor. These are such deep penetrating rays that they have been put to a variety of uses in the fields mentioned below:

■ **New Varieties of Crops.** When seeds of rice, wheat, maize, sugarcane, tobacco, cotton, jute or, for that matter, flowers are exposed to a measured dose of gamma rays, they undergo profound genetic changes with the result that, on sowing, the irradiated seeds give a variety of plants, some of which are high yielding and pest resistant.

■ **Sterile male technique.** There are some insects and pests which mate only once in life. The males of such pests can be reared in the laboratory on a mass scale and sterilized by a dose of gamma rays. When such sterilized males are released in the pest infested area, they mate with their females and die. Because of sterility, no new generation is born and after some time the females also die resulting in the ultimate wiping out of the pest. The eradication of the screwworm attacking the cattle in the United States, is one of the success stories of the sterile male technique which is being applied in the case of fruit flies and other pests in many parts of the world (see article page 18).

■ **Disinfestation of stored foodgrains.** Gamma rays have also been used to destroy insects and pests which infest stored foodgrains. Experiments in many countries have shown that the irradiated wheat and rice do not undergo any significant change in taste or nutritional properties provided

MINING URANIUM FROM THE SEA. Man is not likely to run short of uranium for nuclear power installations. The sea around him is virtually a limitless reservoir of uranium in solution. The Norwegian Current, which flows past the north of the British Isles and along the coast of Norway towards the Arctic Ocean, for instance, carries with it about 250,000 tons of uranium par annum. Over a million tons of uranium pass through the Florida Straits and the Japan Strait each year. For the past ten years scientists in Britain have experimented with different ways of extracting the low concentration (3.3 microgrammes per litre) of uranium in sea water, though these methods are still economically unattractive. One absorbent substance they have used is hydrated titanium oxide which takes up uranium and can then be treated to give solutions in which the uranium concentration is increased ten thousandfold. It gives good results when prepared in the granular form being examined here by a scientist.

Photo © U.K. Atomic Energy Authority

the dose of gamma rays is controlled. Gamma-rays do not induce any radio-activity so that irradiated grains are totally harmless.

■ **Food Preservation.** Fresh fruits, fish, poultry, meat and vegetables decay either on shelves or in cold storage after some time. Experiments have shown that sprouting in potatoes and onions is inhibited by exposure to gamma rays and that certain varieties of oranges, strawberries etc. stay fresh after a light dose of these rays. The shelf life of fresh fish is extended by several days when treated with gamma rays and poultry and bacon remain preserved when exposed to radioactive cobalt. The results obtained in this field are so promising that in the next few years irradiated preserved foods will be a common sight in the world markets.

■ **Cobalt Therapy.** Nearly every modern hospital has what is known as a cobalt-therapy unit. It has a pellet of radioactive cobalt embedded in a shielded chamber which when opened gives out an intense beam of gamma rays. These are used to destroy malignant growth of tumours and cancerous tissues. This has helped many patients not only to live longer but to get completely cured.

■ **Sterilization of Medical Supplies.** The lethal power of gamma rays is also employed in the sterilization of a variety of medical supplies, such as syringes, needles, blades, sutures and hospital linen. In advanced countries, gamma-ray sterilized hypodermic syringes are standard items used for only one injection so that there may not be any cross infection if used a second time on another patient.

■ **Radiography.** Because of the very penetrating power of the gamma rays, they have been used to detect the faults in the castings of thick steel plates, forgings, welded joints, pistons and pipelines, etc. At one end of the defective specimen is placed a cobalt source and at the opposite end a photographic film or a plate. The image showing the voids and defects is registered by the gamma rays passing through the specimen. Industrial radiography is now a well-established technique which has helped to improve the quality of manufactured products and detection of faults in hundreds of metallic items.

■ **Grafting on Wood & Fibre.** Under the influence of gamma rays, grafting of certain chemicals (polymers) has been successfully accomplished on fibres and wood which gives them new properties. Many varieties of soft wood become hard, adding to their usefulness. Similarly, fibre and tex-

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tiles treated with certain chemicals under the influence of radiation may help to produce new materials.

■ **Chemical Compounds.** Gamma rays have been found to have a catalytic effect on certain chemical processes and have also helped to form new chemical compounds (which would not otherwise form under ordinary conditions of chemical reactions). The usefulness of this effect to the chemical industry is, therefore, invaluable.

■ **Thickness and Density Gauges.** Radioactive sources emitting beta-particles (electrons) are used as thickness gauges to ensure uniform density of products like paper. The rollers are pre-set to pass through a certain thickness of paper which is rolled off the production line. The electrons passing through the desired thickness of paper are detected by a counter which in turn controls the setting of the rollers. As soon as thicker paper passes over the rollers, more electrons from the radioactive source are stopped and there is less detection by the counter which brings the rollers closer till the pre-set value is reached.

Thus, defects in thickness of industrial products like paper, can be detected and quality control exercised. Similarly, density of packing of tobacco in cigarettes is detectable with the help of such gauges.

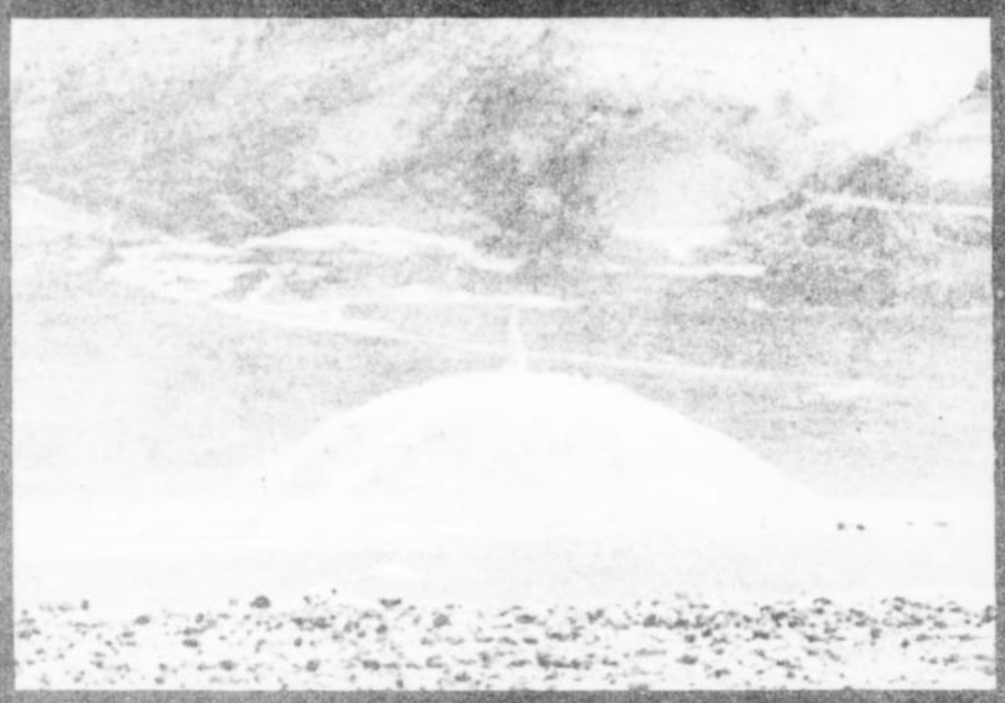
■ **Carbon Dating.** Old archeological fossils and bones contain organic matter and all organic matter contains carbon. All natural carbon has a very minute percentage of the radio-active isotope carbon-14 which has a half-life of about 5,700 years. Thus, if archeological specimens containing organic matter such as bones, etc. are placed before highly sensitive electronic detectors, the faint emission of radiations from radioactive carbon can be registered and counted. As radio-active carbon must have decayed over the period of antiquity, the intensity of emission can determine the age of the carbon and thus "date" the archeological specimen (see article page 22).

The scientist has learnt to tame the atom in the service of man and his quest to discover new horizons will continue as an integral part of the making of the scientist; but scientists do not rule the world. It is the statesmen and politicians who hold the key to two doors; one leading to peace, progress and prosperity and the other to total destruction and annihilation. Let us pray that sanity will prevail and the key shall never be turned to open the second door.

Photos Lawrence Radiation Laboratory, Livermore, U.S.A.

GIANT NUCLEAR BULLDOZERS

The peaceful use of nuclear explosives for large-scale earth-moving might one day enable us to change the geography of our planet. One proposal already made is for the nuclear construction of a new, sea-level Panama Canal, wider and deeper than the present one and withou locks. Above, artist's impression of what this tremendous man-made waterway would look like.



Dream come true?

A SECOND PANAMA CANAL THANKS TO NUCLEAR EXPLOSIVES?

by Carlo Schaerf

AFTER a decade of costly research on nuclear explosives for military purposes, the countries most involved in the production of atomic weapons have begun to consider the possibility of using nuclear explosives for peaceful purposes in civil engineering and industry.

The reasons for this are chiefly economic. Since 1940, astronomic

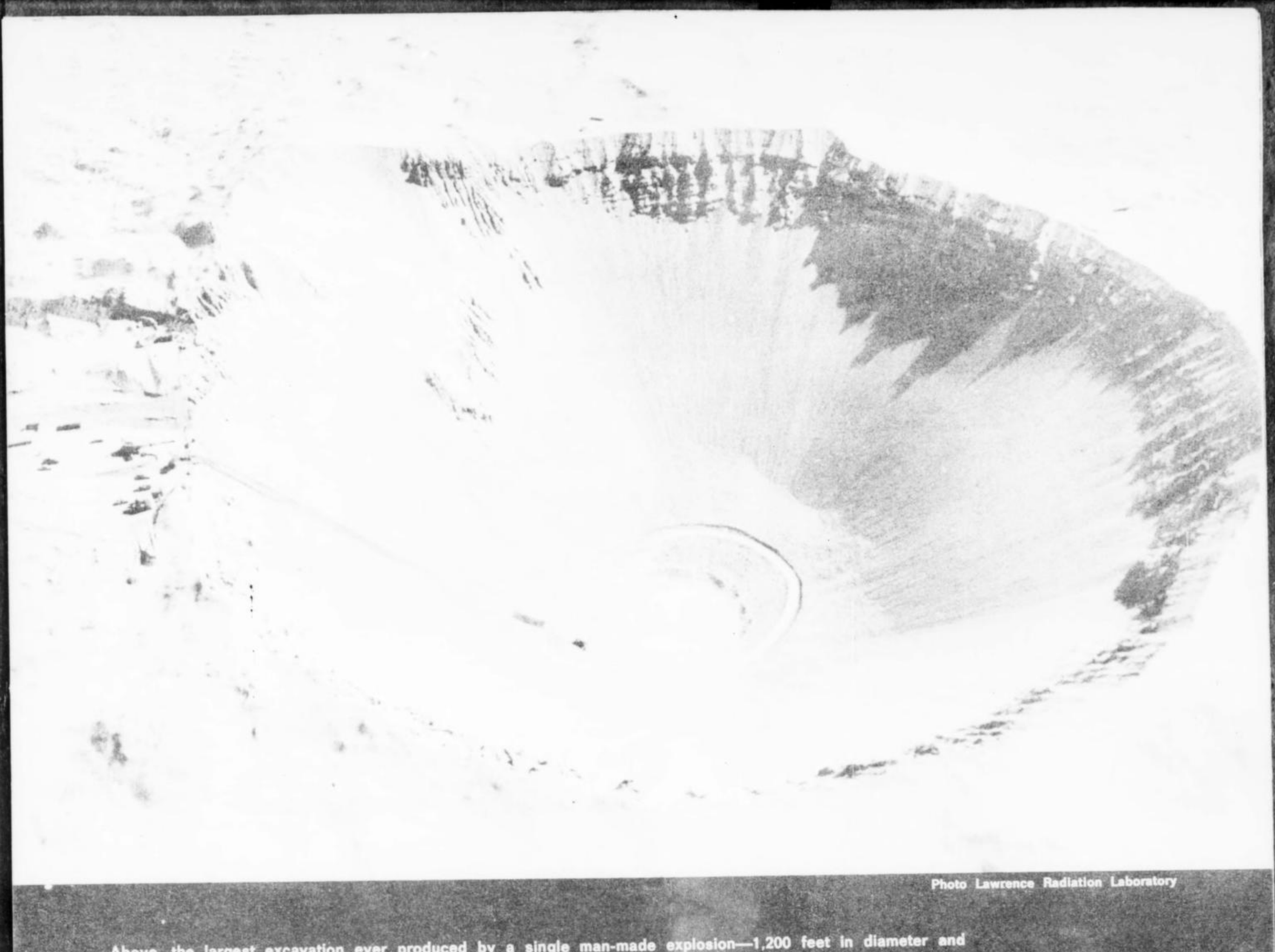


Photo Lawrence Radiation Laboratory

Above, the largest excavation ever produced by a single man-made explosion—1,200 feet in diameter and 320 feet deep—gouged from the desert soil in Nevada, U.S.A. on July 6, 1962, by the use of nuclear energy. Note size of lorries on lip and in bottom of crater. Left, this striking photo shows a huge dome of earth, 600 to 800 feet in diameter, rising nearly 300 feet into the air three seconds after the detonation of a nuclear explosion 630 feet underground. Explosion removed about 7.5 million cubic yards of earth. The experiment, Project Sedan, was the first of a series of tests carried out by the U.S. Atomic Energy Commission under Plowshare, a research programme on peaceful uses of nuclear explosives.

sums have been invested in the development of atomic explosives and in the building up of nuclear arsenals.

The nuclear arsenals of the great powers are believed to contain at present an explosive power equal to about one hundred thousand million tons of T.N.T., that is thirty tons per head of the world population. This tremendous destructive force, stockpiled in the form of atomic weapons, has never been unleashed. The nuclear powers have not only sought to avoid direct military encounters which might have resulted in nuclear warfare, they have also abstained from using "tactical" nuclear weapons in all the local conflicts in which they have become involved.

As nuclear energy has brought a new dimension to the term "explosion", man has begun to think in terms of hitherto impossible things he can now do with explosions. Using the wealth of scientific and technological nuclear data already acquired, he has begun to develop a nuclear explosion technology for peaceful uses.

In addition to the economic reasons for this endeavour, there are psychological and even political ones. Those who had developed the technology of nuclear explosives for military purposes were anxious to demonstrate that it could also be applied for the benefit of mankind. Used constructively, it could increase prosperity and thereby help to ward off the danger of a nuclear holocaust. "Plowshare", the name given to the best-known American programme for the peaceful uses of nuclear explosives, clearly reflects this attitude.

The advantages of nuclear explosives over the conventional chemical types of explosives are their compactness and low cost. Their disadvantage is the possibility of radioactive contamination. So obviously, atomic explosives should be used only in relatively uninhabited areas and when truly massive blasts are necessary: for instance in building new ports in northern Alaska and western Australia, for the construction of a sea-water canal in Libya, or for tapping gas deposits in New Mexico; but they could hardly be used in Europe or in other densely populated regions, except with the greatest caution.

The U.S.S.R. was the first country to officially announce its research programme into the peaceful applications of nuclear explosives. In 1949, the Soviet delegate to the United Nations, Mr. Andrei Vishinsky de-

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Operation 'Dragon Tail' to exploit natural gas

clared: "The Soviet Union is today using atomic energy for peaceful and not for military purposes. We are utilizing this energy for the benefit of our economy. We are levelling mountains, irrigating deserts, opening ways through our forests and tundra. We are bringing life, prosperity and well-being to regions which had been uninhabited for thousands of years."

The first comprehensive study of the utilization of nuclear explosives for excavations was published in 1956 by Soviet technicians.

In 1957, the United States launched a programme of systematic research into all the possibilities of the application of nuclear explosions, on the surface of the earth as well as underground. This was the beginning of the "Plowshare Programme."

Part of this programme was devoted to investigating the possibility of large-scale excavations with nuclear explosives. Ways of reducing, as much as possible, the amount of radioactivity released by these explosives were examined, and the techniques of nuclear excavation were studied: placing of charges, depth of explosions, etc. The possibility of exploding nuclear devices at a depth great enough for the exploitation of minerals was also examined.

The results of these experiments, encouraging from a technical standpoint, have nevertheless confirmed the serious risk of radioactivity.

Among the various possibilities of using nuclear explosives in civil engineering—excavation of canals or artificial harbours, opening of mountain tunnels for roads or railways etc.—the one that is being most seriously considered is the excavation of a second Panama Canal. It is expected that by 1970 the existing canal will no longer be able to cope with all its potential traffic, and even now certain ships, such as mammoth oil-tankers, are too big to pass through it.

VARIOUS projects have already been put forward for the renovation of the existing canal. One project provides for widening it without any change in its height above sea-level, but the number of locks would be reduced. This project would cost $1,000,000,000.

Another project envisages the construction of a second canal at sea-level. This raises the problem of whether chemical or nuclear explosives should be used for the excavations. Using conventional excavation techniques, the construction at sea-level of a second canal in the vicinity of the existing one would cost about $2,000,000,000 (taking into account the need for keeping the existing canal in operation while the new one is being built). As the new canal would pass through densely populated areas, there could be no question of using nuclear explosives.

A route particularly suitable for the use of nuclear explosives engineering exists in a sparsely populated area about 160 kilometres to the east of the present Panama Canal. This route would be about 160 km. long (the existing canal is 80 km. long) and it would pass through a chain of mountains, some of which rise more than a thousand feet above sea-level.

According to approximate estimates, about three hundred charges of nuclear explosives—the equivalent of about 200 million tons of T.N.T.—would be required. The total cost of the excavation would be approximately $1,000,000,000. Radioactive waste from the nuclear explosion would contaminate a vast area, so that some 25,000 people would have to leave and settle elsewhere for a few years.

NUCLEAR explosions contained underground offer the undoubted advantage of not producing any radioactive fall-out, and so can be permitted in places relatively close to inhabited areas. However, even these explosions will need to be confined—at least pending further studies—to uninhabited areas, since they may cause seismic shocks in the vicinity.

Underground explosions are advantageous from the commercial standpoint, for they enable enormous quantities of rock to be broken up at little cost. This would make possible the cheap exploitation of a low mineral and natural gas content which it would be uneconomic to develop with conventional techniques.

These explosions should take place at a depth of from 600 to 1,000 metres. The final result is a cylindrical funnel with a diameter of about one hundred metres and a height of a few hundred metres, filled with shattered rock.

The volume of the cavity is roughly proportionate to the force of the explosion. Around the cavity, huge clefts extend through the surrounding rock. If rocks containing natural gases are blasted, the gases will flow through the fissures in the central cavity where they can be contained and brought to the surface by conventional methods. The cavity can also serve as a reservoir for the gas.

If copper-bearing rocks are blasted, it will be possible to carry out a lixiviation process on the spot by circulating a liquid through the crushed rocks filling the cavity and then pumping it to the surface.

In the United States, numerous projects are under study for the exploitation of natural gas by using nuclear explosives: Project Gasbuggy, Project Dragon Tail and Project Rulison. In addition, the Australian Atomic Energy Commission has expressed interest in the exploitation, by nuclear explosions, of its mineral and natural gas deposits, in co-operation with the United States.

The Gasbuggy Project in the U.S.A. is already well advanced; the first subterranean explosion was detonated under the Leandro Canyon (New Mexico) in December, 1967. No radioactive fallout was detected immediately after the explosion, and underground control apparatus has revealed that the rock funnel that was formed corresponds almost exactly to the size and shape that scientists had predicted. But it will be eight months (the time needed for short-lived radioactive products to decay) before samples of the gas can be taken so as to determine its level of radioactivity and whether gas from the "well" will flow freely and on a commercially viable scale.

ANOTHER aspect of the U.S. Plowshare Programme is the Ketch Project whose purpose is to investigate the use of nuclear explosions to create subterranean reservoirs where natural gas could be stored.

Usually, natural gas is an economic source of energy only in the region where gas deposits are found, because of the high cost of storage. However, if large underground reservoirs could be built to stockpile gas in regions distant from its source, the gas could be conveyed to these places and stored.

There are densely populated areas in the United States without any natural subterranean areas for stockpiling. Project Ketch's first experiment will probably take place in the Spraul Forest (Pennsylvania). The state has authorized the experiment only after obtaining satisfactory assurances with regard to the security of the population of the region.

To sum up, it can be said that projects for the peaceful uses of nuclear explosives are undoubtedly worth-while, notably because of the relatively low cost of such explosives in relation to the tremendous quantities of energy they produce.

Wearing special protective clothing to guard against exposure to radioactivity, technicians in the radiation control laboratory of a nuclear power plant examine an item of reactor equipment. Checks of this kind and stringent security precautions have given nuclear power stations and other installations where atomic energy is used a safety record better than nearly all other major industries.

Photo © EDF, Paris

ISOTOPES WITH 'KID GLOVES'

by Stanley White

WHEN the Second World War ended, despite the preoccupations with the military aspects of nuclear energy, the Great Powers as well as other nations turned their attention to the task of examining its potential for beneficial purposes.

By 1949, the late Sir John Cockcroft, one of the world's pioneers and a sage guide of peaceful programmes, predicted that production of electricity could be achieved within a few years. His prophesy was fulfilled in 1954 when the U.S.S.R. started up a nuclear reactor producing five million watts. Two years later, other stations started operating in France and the U.K., followed quickly by another in U.S.A.

The operation of these stations was watched throughout the world and a great deal of information about them was revealed at the first two conferences in Geneva on the peaceful uses of atomic energy, arranged by the United Nations in 1955 and 1958. These early stations demonstrated both the feasibility and the safety of obtaining power from the atom.

A tremendous amount of work has been going on since that time to improve the methods and the economics of nuclear power production. Within the last three years the breakthrough has come and it is now clear that nuclear power, when used on a large scale, will be cheaper than the coal, oil and gas-fired station to which we have been accustomed in the past.

Because of the breakthrough there has been a remarkable surge in the use of nuclear power. This year will see altogether 94 reactors in use at power stations in 16 countries (1) and their generating power will be more than 14,000 megawatts—a megawatt being one million watts. Many others are being built, most of them much more powerful than at present, so that in four years' time just over twice as many reactors will be producing nearly five times as much power.

Forecasts for the future are being continually revised upwards and at the moment it is expected that by 1980 the quantity of power being produced will reach 350,000 megawatts, enough to run 50,000 large factories or satisfy the needs of more than 100 cities the size of Paris—or to run 350 million single bar electric heaters, all burning at once. They could also, if not under some control, make enough plutonium to make about twenty bombs a day. But the plutonium is much more valuable as a power producer itself.

All this is happening for two principal reasons. One is that power produced in this way is rapidly becoming cheaper, a trend that will continue with advances in knowledge and technology, and with the continuous growth in demand for power. The other is that the elaborate attention to safety is satisfying the stringent demands made by governing authorities, and that operating experience as well as the efforts made by these authorities have done much to reassure the public.

The greater part of a nuclear power

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(1) Belgium, Canada, Czechoslovakia, France, Fed. Rep. of Germany, Eastern Germany, India, Italy, Japan, Norway, Spain, Sweden, Switzerland, U.K., U.S.A., U.S.S.R.

Edible fishbones without waste

station is very similar to any other power station. Heat produces steam, which runs generating equipment, from which electricity is passed through cables. In many conventional stations the heat is created by burning coal, oil or gas; in others energy comes from fast-running water. In nuclear stations the energy gained from splitting atoms of uranium, or in some cases plutonium, is released as heat.

When the splitting, or fission, occurs, it also happens that new elements, some highly radioactive, are created in the core of the atomic furnace. If not contained safely, this radioactivity could cause great harm, but fortunately the ways of controlling it are well known—just as well known as ways of controlling the fires in conventional furnaces. Nevertheless the scientists and engineers have not only readily accepted all conditions imposed on them, but in all matters where radiation is concerned have themselves set much greater restrictions.

Here are some examples of the meticulous way in which the interests of the population are considered.

When the discharge of radioactive wastes into the sea from the Windscale Works in the U.K., was being considered, it was discovered that a food product known as "laver bread" was made from a type of seaweed harvested in the region. Laver bread is eaten by a relatively small group of people living 200 miles away, but since the seaweed tends to absorb radioactive ruthenium, the amount of radioactivity in the discharge had to be set low enough not to affect those consumers.

When determining permitted discharges from the Bradwell nuclear power plant, also in the U.K., it was the fact that oysters might absorb radioactive zinc that influenced the decisions.

Even more selective was the result of an investigation when a pipeline was being prepared to take waste into the sea from the Winfrith Atomic Energy Establishment on the south coast of England. It was learned that one fisherman on the coast consumed an average of four ounces of lobster meat a day, roughly four times the average in the whole country for all sea food. When this was discovered the pipeline was extended at considerable expense to a point further out to sea beyond the area of the lobster beds.

At the Hanford plant in the U.S.A., a survey revealed that some local inhabitants who fished extensively in the river there, were in the habit of eating bones as well as flesh of the fish. Fish tend to absorb radioactive phosphorus in their bones, and since some of this material was included in the low-level discharges of waste, it was considered necessary not only to reduce the rate of discharge of this element but to re-design the effluent treatment plant.

The examples given above were all due to the care taken in seeing that harmful amounts of radioactivity are prevented from contaminating food. That is only one of the factors that are always considered in designing any type of reactor, in deciding where it will be built and in operating it. Many "ologies" have to be called in—meteorology, seismology, geology, biology, entomology among them—all over and above the many sciences concerned with the nuclear and engineering details of reactors.

Whether it is a power station, a research reactor or a laboratory, great care is always taken to remind those who work there that radiation can be dangerous. Terms like "maximum credible accident" are used in discussing reactors long before they "go critical", or reach the stage at which a chain reaction is sustained. Radiation exposure is in terms of "maximum permissible dose" and alarm signals have words like "scram", which has been interpreted as "run like hell".

To the outsider terms like these must seem alarming, but what does the record show? No reactor accident has yet occurred in a power station causing any ill effects to the public. There have been a few accidents in handling materials and in reactors at other plants, which have affected a very few workers, but altogether the safety record has been better than nearly all other major industries.

Because of the unremitting study which has been made, we know far more about the effects of radiation than we do about many of the more common risks run every day, risks which claim human lives. We are still appallingly ignorant, for example, of the dangers arising from pollution by motorcar exhausts or from other forms of industrial pollution in the atmosphere.

In fact, nuclear power plants will help considerably to relieve the problem of air pollution because what little escapes from them is carefully filtered and even then only released at heights which ensure that radioactivity is practically unmeasurable by the time it reaches ground level. Strangely enough, coal-burning plants release more biologically significant radioactivity to the atmosphere than nuclear power plants.

One of the problems that will grow with the industry is how to dispose of radioactive wastes. The greater proportion of these are comparatively easy to handle since they do not contain dangerous quantities of radioactivity. But there is a very small percentage which is highly radioactive and the quantities will of course grow.

CONTINUED ON PAGE 44

Scientists are using nuclear techniques to develop a new arsenal of weapons against insects which destroy food and carry disease. In Asia, the rice stem borer destroys 14 per cent of the yearly rice harvest. In the U.S.A., the corn earworm does $400 million dollars damage annually. Here, a biologist studies locusts at the Argonne National Laboratory, Illinois, U.S.A., where some of these new methods are being perfected.

Photo USIS

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or, the tri

OUT of the several millions of species of insects which exist only a few are harmful to man and his environment. Yet this small percentage causes untold misery. It is estimated that a fifth of the food produced in the world is lost, much of it going directly to feed these pests.

They cause immense losses among animals reared for food or domestic use; they can wreck buildings, destroy forests and bring death to human beings. Their ravages have been recorded from the time that writing was invented. In Africa, up to a half of the continent's dried fish is lost to insects, and about 50 million people could be fed each year by the grain destroyed through their ravages.

After many centuries of war against harmful insects, there are indications that man is gradually winning and that atomic energy has now added a powerful weapon to the armoury of control methods which have been developed. These include insecticides, scientific

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EYMOONING IN CAPRI

bulations of a fruit fly in the modern atomic age

by Donald A. Lindquist

methods of growth and storage, breeding varieties of plants which are resistant, encouraging populations of beneficial insects that kill pests, and making scientific use of diseases that also kill them.

In most cases, the first line of defence is the use of insecticides and this will continue to be so for many years. Unfortunately, they have several disadvantages: they kill many beneficial insects, they raise problems of potentially hazardous residues in crops, meat or milk, and eventually some insect strains become themselves able to resist their effects.

With techniques which have been developed from atomic energy, control methods are emerging which are more precise in their application and seem to eliminate the disadvantages. Essentially, atomic energy can be used in two basic ways in the fight. One of these is to take advantage of the effects of radiation in direct attack. The other is to utilize the radiation from the radioactive atoms of elements—radioisotopes—for marking insects and materials, thereby gaining information of their habits, life-cycle, the structure of their bodies, their food, the effects on them of radiation and chemicals, and all the other factors necessary for planning effective campaigns.

The International Atomic Energy Agency (IAEA) and the Food and Agriculture Organization (FAO) are actively collaborating to explore and develop all the highly varied nuclear methods now available both for waging the war and for obtaining the intelligence essential for the "field troops". They are supported by entomologists and scientists of many countries and by other international, regional and national organizations.

The use of radiation to affect insects is emerging as a successful way of control for a number of them. It has been found that some, when exposed to the proper amount and type of radiation at the correct time during their development, become incapable of reproducing although normal in all other respects. The radiation induces sterility, and when a sterilized insect mates either with a normal insect or another which has been sterilized there is no progeny. This fact has led to the "sterile male" method of control or even eradication of insect pests.

The technique, stated very simply, is based on the fact that the wild normal female of a species will mate with a sterile male as freely as with a wild normal male. Therefore, if nine sterile males and one wild male are present, nine times out of ten the female will mate with a sterile male and she will produce no young. The more sterile males present, the less the chance of a mating between a wild male and a wild female. If sufficient sterile males are present during several successive generations, the population of wild insects declines to zero, provided reinfestation does not occur.

The first example of the practical application of the sterile male technique was in the south-eastern United States against the screwworm fly, which lays its eggs in the wounds of warm-blooded animals. The developing larvae often cause death unless the animal is treated, the result being great losses of livestock and wild game animals.

A "fly factory" was constructed in Florida to rear and sterilize millions

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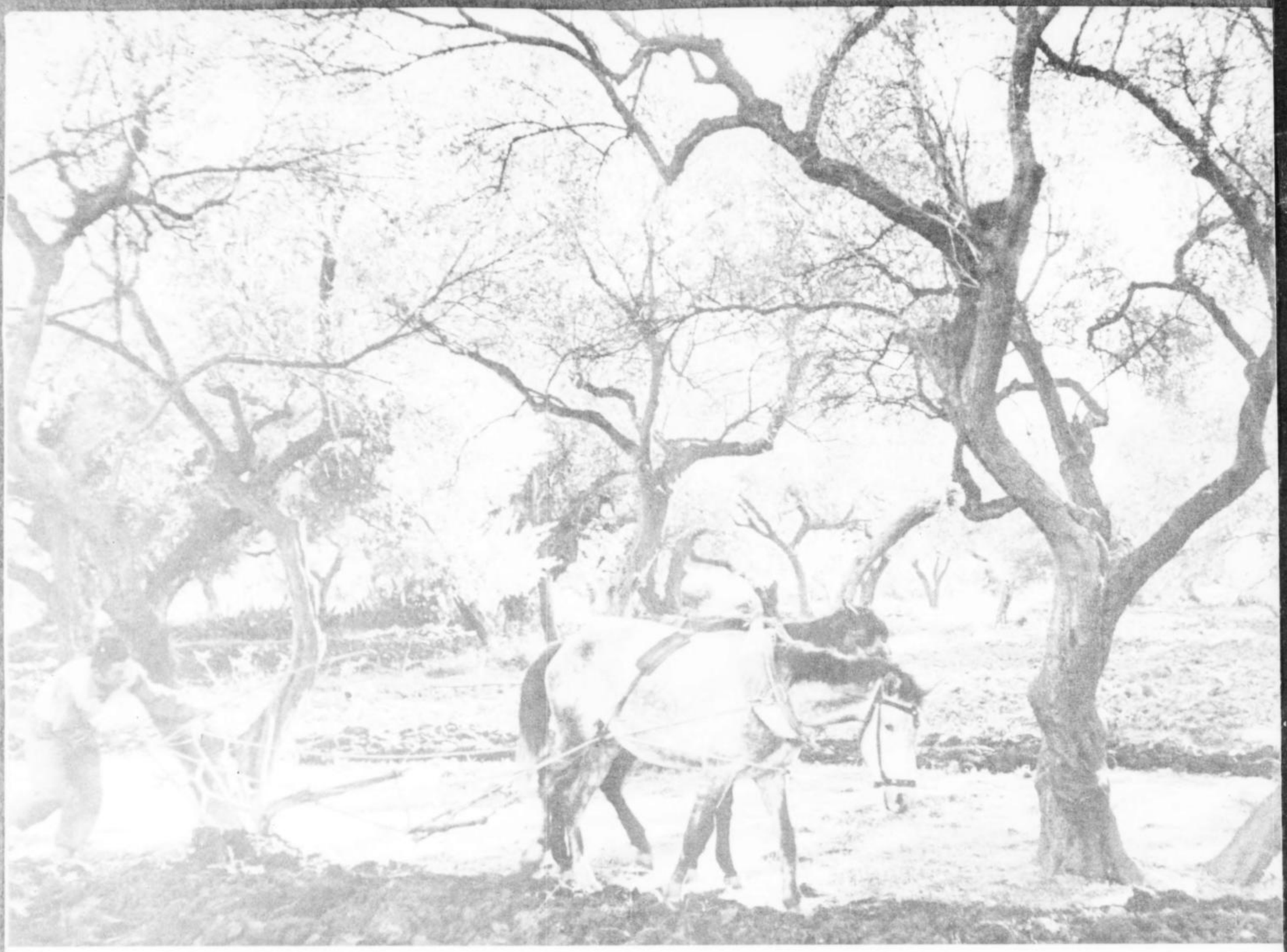


HONEYMOONING IN CAPRI *(Continued)*

50 million sterilized flies parachuted each week

of screwworm flies a week; these were then released from aircraft over the entire infested area. The results were outstanding. This serious livestock pest was completely eradicated simply because the wild female screwworm fly mated more often with sterile laboratory-reared flies than with other wild flies—there were many more sterile than normal males present.

The cost of the programmes was about $10 million; but the screwworm fly was causing an average loss of about $20 million a year to the livestock industry in the region. This approach has now extended to the south-western United States and northern Mexico.

This success provided a stimulus to begin research on several other species of harmful insects. One of these is the Mediterranean fruit fly (Medfly for short, *Ceratitis capitata* to the entomologist) which attacks many types of fruit and causes serious losses. Very much like the common housefly in appearance, it is spreading far beyond the Mediterranean and in recent years has established itself in the Americas. Research during the past few years has demonstrated that the sterile male technique is applicable in controlling this insect.

At the present time a major demonstration is being conducted in Central America. This programme is being carried out on behalf of the U.N. Development Programme as a co-operative undertaking by the IAEA, FAO, the International Regional Organization for Plant and Animal Protection (OIRSA), the governments of Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama (all members of OIRSA), and the U.S.A.

Many of the problems associated with enlarging a laboratory project to a large-scale field project have been solved. At the present time more than 50,000,000 of the flies are being reared and sterilized each week. Most of them are released from the air over two experimental areas. At the same time research goes on to achieve more efficient methods of rearing, handling, releasing, trapping and transporting.

It is anticipated that upon completion of this project, methods will have been developed which can be used for large-scale eradication or control programmes against the Medfly.

Additional research for the same purpose is being conducted in Italy, where the International Atomic Energy Agency is co-operating with the Italian Atomic Energy Commission in demonstrating that the sterile male technique is effective, and experiments during 1967 on the islands of Capri and Ischia quite conclusively demonstrated its potential. This year experiments on the use of helicopters for releasing flies, and to determine the minimum number of sterile flies necessary to achieve eradication under conditions in Italy are being made.

The sterile male technique appears to be particularly promising for control or eradication of the olive fly. This insect, also very similar in appearance to the housefly, attacks, as the name implies, the olive fruit. Thus its maximum distribution is easily determined.

Preliminary work in Greece, partially supported by the International Atomic Energy Agency, has shown that the technique is effective in cages constructed over olive trees. The experiments will be on a wider scale in the next few years. The one remain-

Olive groves, economic mainstay of many Mediterranean farmers, are often ravaged by a fly which destroys the olives. Promising trials have recently shown how the olive fly may be controlled and perhaps eradicated by sterility-inducing irradiation of male insects.

Photo © Henri Cartier-Bresson

ing problem to be solved is how to rear large numbers of flies cheaply, and research is being carried out by the IAEA, at its Seibersdorf Laboratory near Vienna, Austria, and in Portugal and Spain.

Agricultural scientists in Canada and the United States have proved that the codling moth, which causes damage to apples, pears, and certain other fruit all over the world, can be controlled in this way. Insecticide sprays are effective against it but often kill beneficial insects, causing increased damage to the fruit by other species of harmful insects. It is considered that the sterile male technique can be used for codling moth control or, under isolated conditions, eradication.

There are of course great differences in utilizing the sterile male technique for insect control as compared with insecticides. Insecticides can be effectively used by an individual olive producer in his olive grove. If he were to use the sterile olive flies they would soon disperse away from his own trees. The sterile male technique is essentially for use by one or more countries over large areas. The problem of reinfestation must be considered if eradication is the goal.

The technique may be particularly effective against new introductions of harmful insects into an area or country, if the proper research has previously been done. The Medfly was first found in Central America in the mid-1950s. If at that time the techniques had been developed, a relatively inexpensive programme would have eradicated the pest.

The same can be said for the few times that the pest made its way into the United States and the one time it was found in Santiago, Chile. On these occasions, repeated insecticide sprays have been used to eradicate the Medfly. The sterile male technique would be very useful under these conditions, and the time may well come when it will automatically be put into operation to prevent new threats from becoming serious.

The insects already mentioned are only some of those now being studied as suitable for atomic means of control. There are many others, some of them much more dangerous both to food and health. Discussions at the most recent international meeting in Vienna ranged over ticks, aphids, mosquitos, wasps, locusts, sugar cane borers, cotton weevils, pine caterpillars, and the tsetse fly—again to mention only a few. Much information was also revealed to assist in making better use of beneficial insects, of which the bee is a notable example.

A word about the tsetse fly, whose ravages make large areas of Africa precarious for men and animals. It is too early to raise high hopes about defeating it, but enough has been learned to indicate that, difficult as the problem is, the new nuclear techniques, linked with other scientific approaches, might finally bring relief.

Many years of research lie ahead and much money will have to be spent—if it can be found. Just as an indication of the task, we still have to breed in captivity a tsetse fly vigorous enough to compete with the wild specimen. Substitute foods have not yet been as effective as the warm blood of living animals.

RADIOISOTOPES have provided scientists with ways of probing secrets of nature on the most minute scale ever achieved. They have been widely used during the past 10 to 15 years in research associated with insect control. "Labelling" insects with a material such as radioactive phosphorus, has enabled entomologists to follow the movement of insects under natural conditions.

For example, if Medflies tagged in this way are released in an orange grove, their movements can be accurately followed by trapping, and using a Geiger counter to find if any are radioactive. In this way it was found that Medflies do not ordinarily move more than a few hundred metres under favourable conditions. This is a very important fact to take into consideration in using the sterile male technique. Other insects fly several miles.

Another useful application of radioisotope labelled insects is in population density studies. A known number of tagged insects are released and a few days later traps are set up. The ratio of tagged insects to untagged insects may be used to estimate the wild insect population in the area.

When no adequate trapping technique is available, insects can be tagged with gamma-emitting radioisotopes such as cobalt-60. These can be detected by portable instruments at distances up to several meters, enabling the precise location of the insect to be determined at night, in the soil, in tree trunks, and in other places where it cannot be seen.

How is this labelling, or tagging, done? The radioisotope can be included in the media used to grow the insects, fed to the adult insects, or applied to the body surface. In certain cases a tiny piece of radioactive wire is glued onto the insect. The procedure varies with the insect and with the information needed.

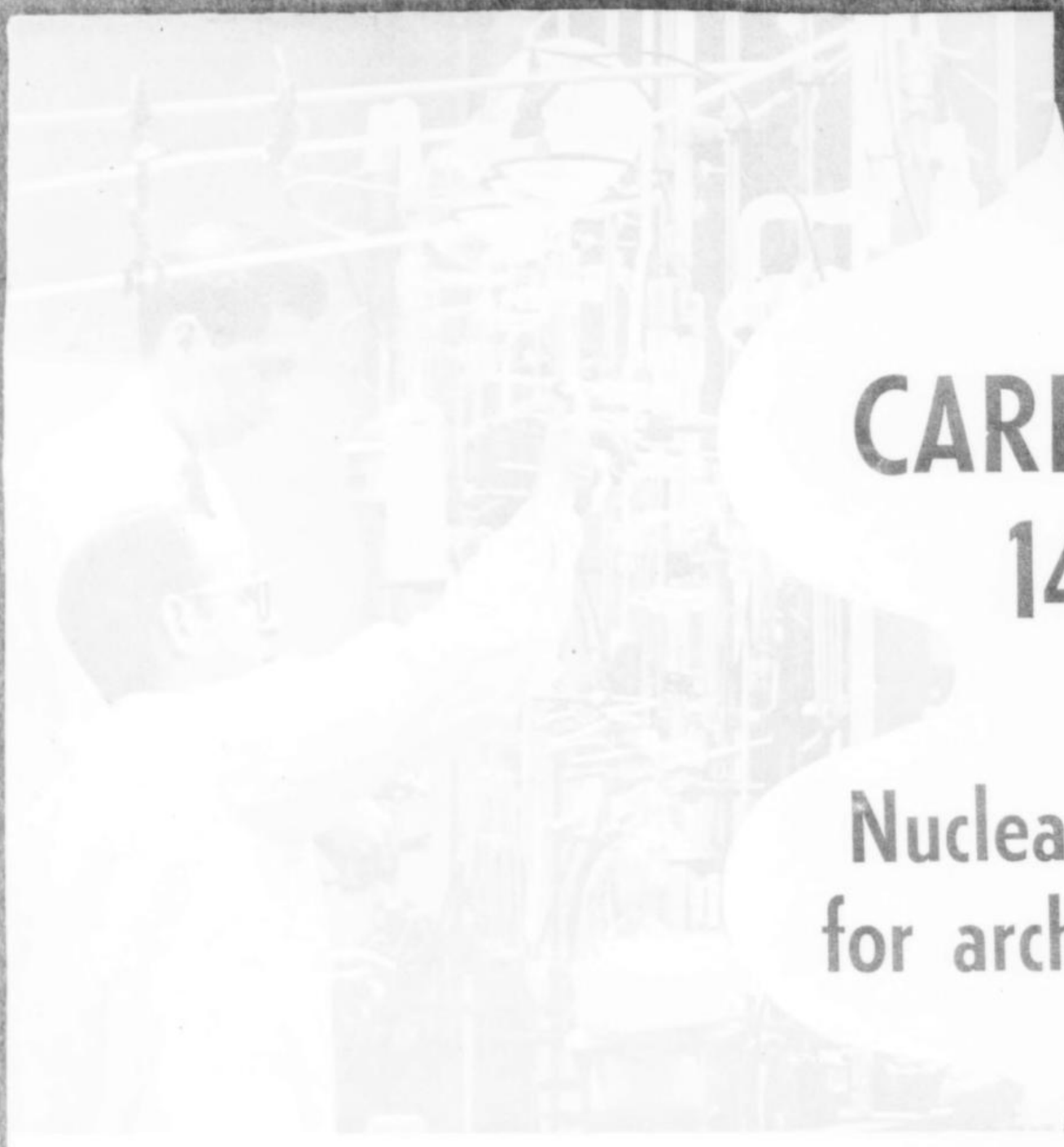
The use of radioactive materials has vastly increased our knowledge of insecticides. One or more radioisotopes are incorporated into the molecules of the chemical during its manufacture. This does not affect its biological action, but enables measurements to be made of extremely small quantities. Entomologists and chemists have in this way been able to study what happens to the material in insects, animals, soil, plants, etc.

The fate of insecticides in various biological systems is important for several reasons. It has been found that some are biochemically converted in plants and animals to compounds and become less poisonous or even non-poisonous to insects. Others become more poisonous. It is important to know these facts before the compounds reach the public.

Radio-labelling has been widely used to study how insecticides kill. The objective of this research is to make new insecticides which will kill selectively without ill effects to man, animals and beneficial insects. It is hoped that this work will ultimately lead to production of efficient selective insecticides which can be safely and economically used.

There are many uses for radioisotopes in fundamental studies of insect physiology. By tagging certain naturally occurring compounds in insects, it is possible to study many of the enzymes and hormones that control their development and behaviour. Once these physiological processes are understood, it may be possible to alter them and perhaps to control the pest.

As can be seen from this brief description, atomic energy is a valuable tool in controlling harmful insects. It will become more valuable in the future as more entomologists are trained to take advantage of the exciting possibilities it opens up.



CARBON 14

Nuclear clock for archeology

by
Willard F. Libby
Nobel Prize, 1960

Will radiocarbon, a remarkable device for dating geologic time, show us that the dawn of man's history was more remote than we think? Carbon-14 has solved many problems for archaeologists and historians, but has also posed quite a few new ones.

We are made of three things in essence—carbon dioxide, water vapour, sunlight—and a pinch of salt!

Photosynthesis produces green plants by the conversion of carbon dioxide and water to plant materials, using the energy of sunlight.

Nature produces radiocarbon by the irradiation of the air by cosmic rays. Radiocarbon has an average lifetime of 8,000 years and a half lifetime of about 5,700 years; a good part of the radiocarbon in our body was produced before the dawn of history.

So as we see, the material from which life grows comes from the air and comes from the carbon dioxide in the air, and in eight thousand years the atmosphere will have been very thoroughly mixed by the winds.

We know now, incidentally, from our work on radioactive fall-out, that the mixing process takes only five to ten years at the most before the atmosphere is thoroughly mixed. So even though the radiocarbon is produced at greater altitudes than ten miles, in a matter of a few years it will have come down to the lowest levels where it can be incorporated into plants.

The plants eat the radiocarbon from the cosmic ray manufacture and then we eat plants, so all living things become radioactive with carbon-14.

History is a really very recent matter in terms of radiocarbon. Our oldest historical records are less than one half-life of radiocarbon. In terms of the age of the earth, however, radiocarbon is short-lived. The age of the earth is something like 5,000 million years, which is a million half-lives of radiocarbon. Radiocarbon has little application to the broad sweep of geological processes, but it does have application to human history.

This is how it works. In the topmost layers of the atmosphere, at altitudes of about 50,000 feet, cosmic rays produce radiocarbon by converting the nitrogen into carbon-14, with a different chemistry. Carbon in air will burn and the product is mainly carbon dioxide. Carbon dioxide is our substance.

Most important for radiocarbon dating is that our contact with cosmic rays exists only so long as we continue to eat. As long as we are alive and continue to eat, we continue to absorb and ingest radiocarbon.

The carbon-14 atoms in our body, which are 8,300 years old on the average, have been many times in the air as carbon dioxide, have been brought down to the earth as part of the plants, or more likely have been dissolved in the great depths of the ocean. In this great span of time, the winds blow the radiocarbon around, the ocean currents mix it, so that even

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WILLARD F. LIBBY, *Nobel Prize Winner for chemistry, 1960, is a leading international authority on radiocarbon dating, and has been active in the field of atomic energy and nuclear studies for a quarter of a century. A member of the U.S. Academy of Science and many other scientific institutions both in the U.S.A. and other countries, he is the author of numerous articles, appearing principally in scientific journals. Professor Libby's text is based on an address he delivered at the International Atomic Energy Agency headquarters in Vienna, in 1966.*

Carbon-14 is the best example of a planetary hour-glass. It has been produced in the upper atmosphere at a virtually constant rate for the past 50,000 years. The C-14 cycle, then, is like an hourglass in which the sand in the upper part is replenished as fast as it runs out of the hole in the waist. Newly produced C-14 is taken up by all living plants and animals. All carbon in living organisms contains a constant proportion of C-14. When a plant or animal dies no more new C-14 is added but the old C-14 continues to run out, and starts to measure time as an hourglass should. Ancient objects can be dated by determining how much C-14 remains and then calculating back to the time when the radioactivity from the C-14 was the same as that now found in a living organism. The processes used are very complicated, involving the reduction of the carbon to a gas either by burning, or chemically (photo left) and counting the C-14 disintegrations in the gas.

Photo U.S. Geological Survey

though the cosmic rays vary very strongly with the geographical latitude —being much more intense in northern and southern latitudes than in the equatorial—after this great period of time we should expect the distribution over the earth to be uniform.

We do indeed find that, in Nature, living matter such as pieces of wood and flesh, or other living material from various species and various locations, all have the same amount of radiocarbon in them (per unit amount per gramme of carbon). That is, the composition — the concentration — of radiocarbon in the carbon of the living matter is uniform over the entire world and in all species, because of this continuous mixing. As long as we live, we are part of a giant system which is continuously stirred. We belong to the oceans and to the air and we are all part of the same system, but our connexion is through our mouths, through food.

Radiocarbon dating, operates on this basic principle. Once we die, we stop eating. Once we die, the ingestion of radiocarbon is terminated. Of course, it is a characteristic of all radioactive materials that they themselves disintegrate and disappear and transform. In the case of radiocarbon, the transformation occurs at the rate of 50 per cent every 5,700 years, and the result is the re-formation of the original nitrogen from which the carbon came.

In the course of this transformation, a radiation is emitted which allows us to detect the death act of the radioactive atom. If we put carbon dioxide gas (obtained by burning a piece of wood) in a counter, by listening to the count-rate we can detect the disappearance of the carbon atoms as they are reconverted into nitrogen.

It takes somewhat over 4,000 million radiocarbon atoms to give one disintegration per minute, because the average life of radiocarbon is 8,300 years, or 4,400 million minutes. So 4,400 million radiocarbon atoms are needed to get a detectable radiation in the carbon dioxide in a counter.

Although this seems a large number of radiocarbon atoms, it is not large percentage-wise. The total number of atoms in a gramme of carbon is 10^{12} times this—that is, we have only one radiocarbon atom in a million million ordinary carbon atoms. This is the standard concentration in living matter. And at the time of death, all living things begin with this rate. They will have a count rate which corresponds to the occurrence of about 66,000 million radio atoms per gramme of carbon—that is a total disintegration rate of about 15 per minute per gramme.

The first thing in our development of radiocarbon dating was to prove that it was indeed so, that radiocarbon occurred in all living tissues and at the expected uniform level. This was done fairly quickly and it was gratifying to find that our rather simple-minded theorizing was correct.

Now, as the years have gone by and more accurate measurements have been made, we find that it wasn't actually absolutely correct. There are very tiny differences between species —for example, sea life has just a little bit less radiation than it should have, for there seems to be a kind of natural barrier against carbon dioxide in the air dissolving in sea water. It doesn't dissolve rapidly.

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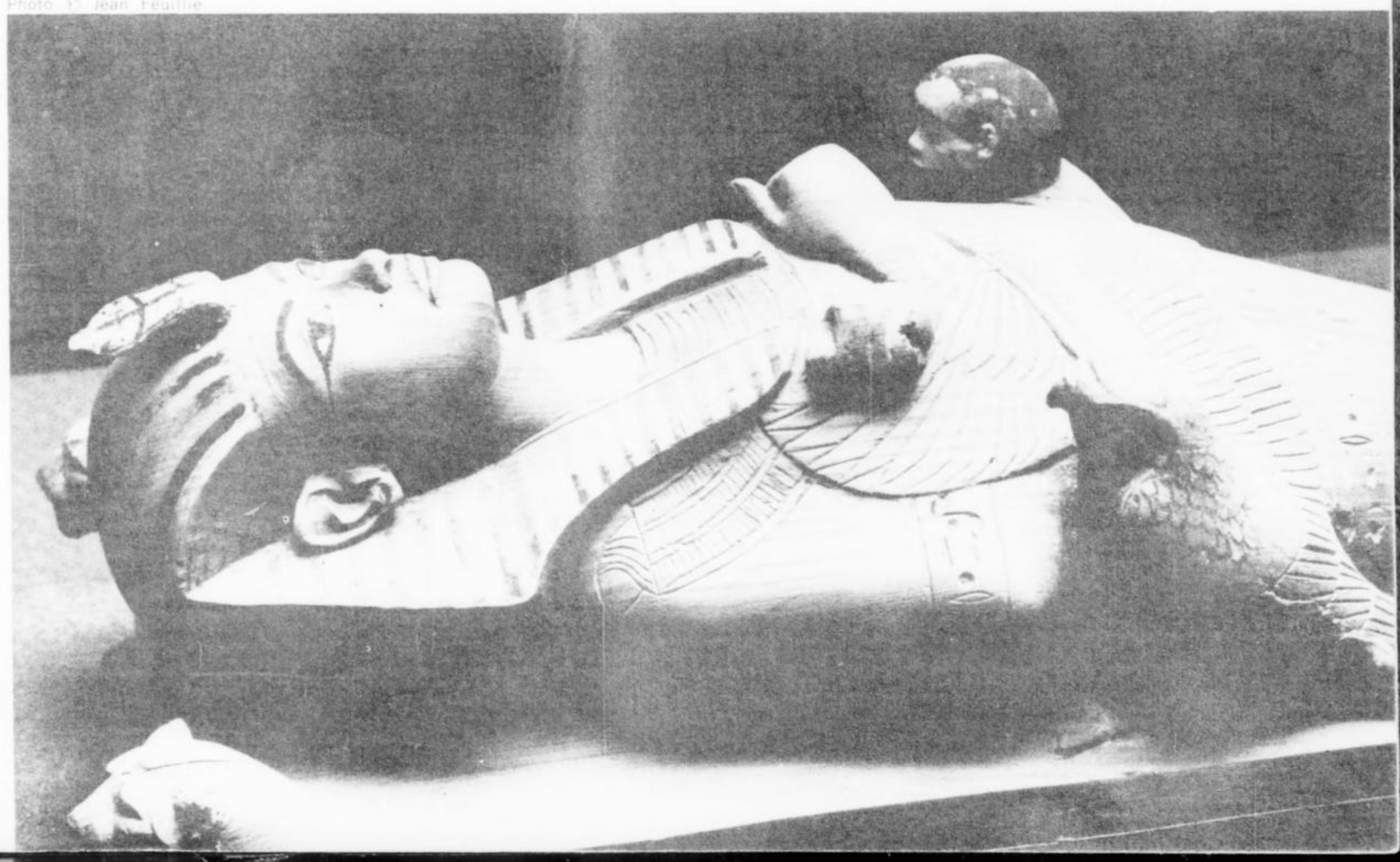
Photo © Jean Feuillie



Reproduction carved in cedar wood of the fabulous gold sarcophagus in which the mummy of Tutankhamen (1361-1342 B.C.) was placed in the Valley of the Tombs, near Luxor, Egypt. It is one of the great wealth of objects—2,000 in all—recovered from the royal tomb on its discovery in 1922. Scientists are now checking all the ancient dynasties of ancient Egypt to see how close they concur with the established historical dates.

Dating the Dead Sea Scrolls

Photo © Toni Schneiders - Rapho

WORLD'S OLDEST TREE AND CARBON-14

To find out the age of a tree, all we need do is count the rings in the trunk (right) since each ring represents a year's growth. Wood, which contains radiocarbon, can be used for a simple countercheck of results obtained by carbon-14 dating. The oldest living organism on earth is the American bristle cone pine (left) which has lived for 6,000 years or over. With the help of this tree it has been found that beyond 3,500 years ago, dates obtained by carbon-14 diverge increasingly from established historical dates. Carbon-14 seems to "rejuvenate" a material by 200 years at 3500 B.C. and by 800 years at 4000 B.C.

In a general way, we went forward in our innocence finding that everything worked. I have never been connected with such a lucky piece of research. For example, we supposed that the oceans mixed rapidly, and that most of the hold-up of radiocarbon would take place in the ocean which has far more carbon dissolved as sea salts than is contained in all living matter.

We had to calculate from our knowledge of the cosmic ray production rate what the expected concentration would be. If we only considered the biosphere [the part of the world where life can exist] its expected concentration would be thirty times greater than the level which we actually found. However, we rightly guessed that the oceans would mix rapidly and that the concentration in the biosphere would be thirty times lower than the rate of cosmic ray production would seem to suggest.

There is, in fact, thirty times more carbon in the ocean than in the whole of the biosphere. We were lucky there. We were lucky also in supposing that the turnover of humus is rapid, or rather that the hold-up is not serious in the terms of the whole inventory, although we knew full well that coal and oil and all organic matter of this sort would be long since purged of radiocarbon by radioactive decay.

The next stage of the research was to see if it was really so that 5,700 year-old mummies showed only half as much radiocarbon as a person living today. There are no 5,700 year-old mummies, the oldest ones are 4,800 years old—that is, ones whose ages are relatively well-known, so that we could use them for a check. These are the first dynasties of Egypt, where the oldest recorded history applies.

When one goes back to the dawn of history, the certainty with which the historians know the dates decreases. I would say, from talking with historians, that they would stake their lives on 3,750 years, but with anything older than that, they begin to shake a little bit. But they can go back to Sesostris III in the 12th dynasty of Egypt and argue very firmly.

So we had two periods in which to check our method—one was 3,700 years and the other was about a thousand years preceding that. We were very fortunate in that our checks —with one or two exceptions—were excellent. One of the exceptions was discovered when we worked in collaboration with the distinguished Oriental Institute of the University of Chicago with the great collection that James H. Breasted had made from Egypt. And our third object from Egypt turned out to be modern! It was one of the famous U.S. egyptologist's prize collections, supposed to be from the fifth dynasty, as I remember. This was a dark day.

But having succeeded on the first two measurements, the people in the Institute checked their records and said they thought it was entirely possible that the U.S. egyptologist had been hoaxed. The only interpretation we have for that measurement today is that he was "sold a bill of goods".

But by and large, we have had few shocks. For example, on Stonehenge we obtained 3,700 years, which agreed excellently with the predictions of Professor Stuart Piggott, the great scholar of Stonehenge.

Throughout Roman and Egyptian history, we have no disagreements. We haven't had very many measurements to make because in general the archeologists know the dates better than we can measure them, and it is usually as a favour that they give us samples.

We take about an ounce of material to make a measurement—about 20 to 30 grammes of fairly rich carbonaceous material is the normal amount, and in some of these objects that is too large an amount to be spared. On the other hand, we can sometimes make do with samples which would otherwise not be useful. For instance, we dated the Dead Sea scrolls—the manuscript of the book of Isaiah—by using the linen wrapping in which it was found.

There has been no serious shortage of materials back to about 3,700 years with which we could check the accuracy and reliability of dating by car-

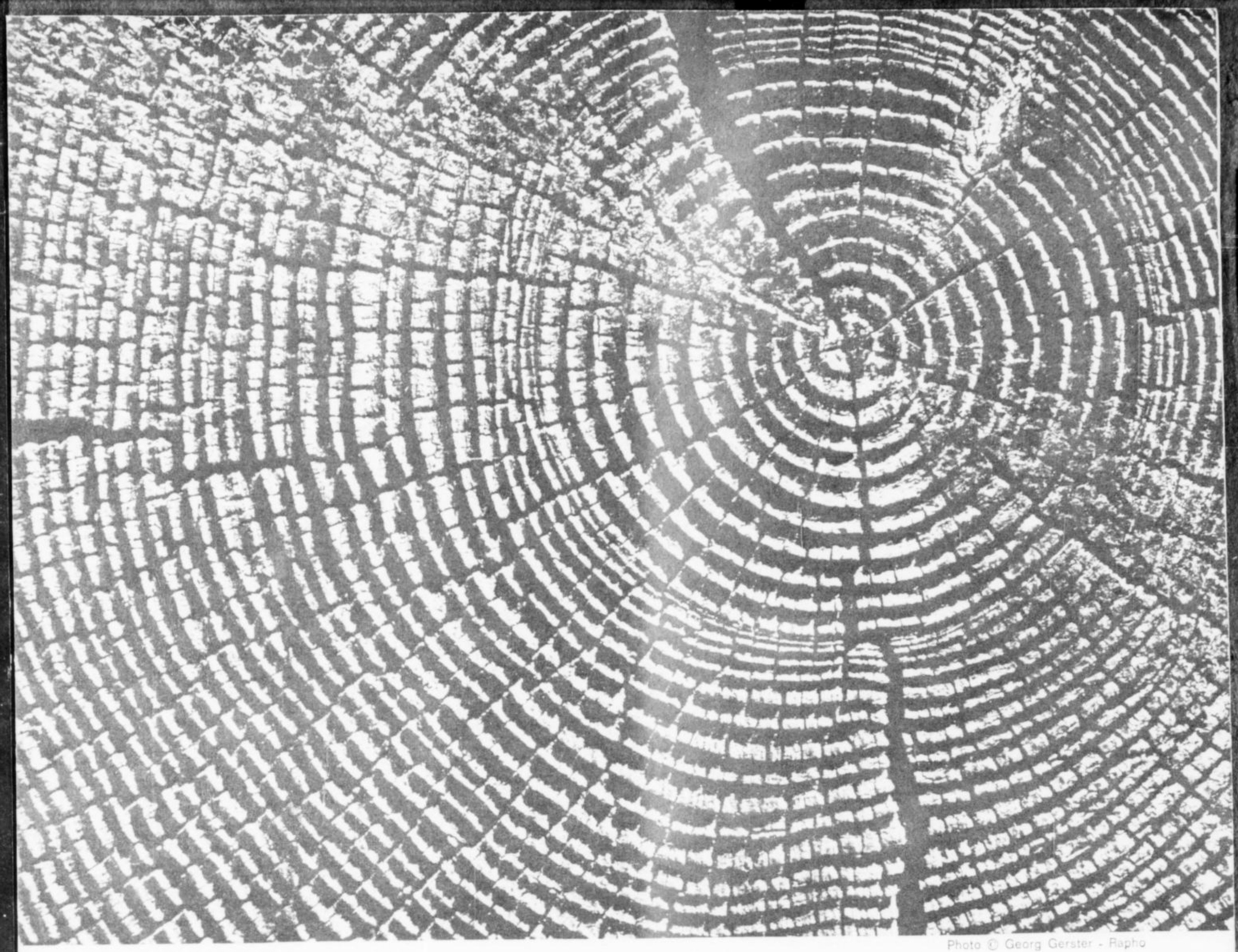


Photo © Georg Gerster - Rapho

bon-14. And the answer is that the method seems to be reliable to within the error of the measurement as it existed when we began the method in the early 1950s—an error of about ± 100 years or so.

More recently, extremely careful measurements with very accurate instruments have shown that there are systematic deviations, indicating that the rate of radiocarbon production was not strictly constant.

A rate had been an implicit assumption at the outset. When we compared the radiocarbon in an Egyptian mummy with that in a modern man, we assumed that he lived under similar conditions. This assumed that the radiocarbon production rate at that time was the same, that cosmic rays were the same, and that the amount of ocean water was the same—in other words, that the amount of carbon dilution was the same. We have fairly good evidence that the ocean hasn't changed much, either in composition or level, in 5,000 years. This is a very brief time in geological history.

But the problem of cosmic rays is an open question. People have very little understanding of the origin of cosmic rays. We believe that they come from outside the solar system, and have very good evidence for that. But there are various subtleties about even that because, even if they come from outside the solar system, they have to reach the earth.

Cosmic rays are deflected by matter and particularly by magnetic fields, and the sun is continuously sending off ionized matter in clumps, which carry locked-in magnetic fields capable of deflecting cosmic rays.

According to a study made by Dr. Hans Suess, of the University of California, San Diego ("The climatic changes in cosmic ray production rate of radiocarbon") when there is hot weather for as long as a century, it means that the sun is specially active in sending out lots of plasma, and therefore the production of radiocarbon is especially low. In consequence, during that century radiocarbon dates are too old.

Conversely, when there is a century or two of cold weather, the sun is inactive and the cosmic rays come in better, so radiocarbon dates are too young. The errors are about ± 50 years, so it is almost within our experimental error.

Dr. Suess has been very energetic in making lots of measurements, using tree rings for his materials, so he knows the dates quite accurately, and I think there is little doubt that he is right.

We have been doing work on English manor houses in recent years; the historical dates are excellently known for many of these homes and we find our agreement has improved if we make Dr. Suess's little corrections. He has made the point that there is a deviation which is small but measurable. But by and large the agreement has been gratifyingly good.

The consequences of the agreement are interesting—namely that the cosmic rays, the level of solar plasma and the earth's magnetic field have remained

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RADIATING MONSTERS

Several nuclear dating techniques (see box below left) now enable scientists to determine the age of the extraordinary prehistoric animals which roamed the earth millions of years ago. What is usually dated, is not the fossil itself, but the sediments surrounding it, that is, the actual environment in which it lived—the nuclear scientist works hand in hand with the geologist investigating the strata. Left, this strange mammal was discovered close to the palace of an Egyptian queen, Arsonoë, from whom it takes its name, Arsinoitherium. Living 40 million years ago, he was a newcomer compared to the Pterodactyl (below), a winged reptile, which goes back 180 million years, but an earlier inhabitant of the earth than the cave hyena (right), one of the great carnivorous animals of Europe a mere 50,000 years ago.

Photos © Paul Almasy, Paris

Photo © Jean-Marie Baufle, Paris

LONG-LIVED NUCLEAR CLOCKS

The time span for dating materials by the carbon-14 method is from 1,000 to 50,000 years. As this is a relatively short time measured on the geologic scale, scientists have searched for and have found in nature other nuclear clocks with far longer lives. Their dials tell the time not merely in centuries and thousands of years, but in millions and thousands of millions. The long-lived clocks measure age in the same way as carbon-14—by the time taken for their radioactive atoms to decay, but their rate of decay is far slower than that of carbon-14, slow enough in fact for them to have survived in certain rock and mineral formations. By studying the natural decay of uranium to lead, for instance, scientists have been able to calculate the age of the earth as 4,500 million years. Other materials present in rocks have provided a number of nuclear dating methods. With potassium-argon it is possible to tell the age of rocks 100,000 to 10,000,000 years old; calculations based on the natural fission of uranium-238 permit the dating of materials up to 1,000,000,000 years old; and the rubidium-strontium method has a time span of over five million years. Nuclear dating methods, which are constantly being improved, have already contributed substantially to man's knowledge of his planet's history.

NUCLEAR DATING METHODS
Time span (years)

Carbon-14	1,000 - 50,000
Potassium-argon	100,000 and up
Rubidium-strontium	5,000,000 and up
Uranium 238	100 - 1,000,000,000
Uranium lead	200,000,000 and up

The oldest Englishman: 10,400 years of age

essentially constant and that the ocean depth has not changed appreciably. This is not a very surprising result.

But when we finish with recorded history, we have not used even half the radiocarbon. The way radioactive decay goes, you lose half in one half-life and then you lose half of the remainder in another half-life so that at the end of two half-lives, that is 11,400 years, you still have 25 per cent left.

It will take ten half-lives—57,000 years—to get down to a tenth of one per cent. Even with our most sensitive methods of measurement at this time, we cannot measure a tenth of one per cent of the natural life.

So radiocarbon will not apply to things older than about 50,000 years; in fact when we go back to 40,000 things get a little uncertain. But between the dawn of history—that is 4,800 years—and 40,000 years is a great span of time.

Within the span of radiocarbon there were three Ice Ages. It appears that an Ice Age is world-wide—at least it would be surprising if it were not. It certainly is hemisphere wide. So if we find a glacial advance occurring in North America at a certain time, we ought to find it occurring in Europe at the same time. This was one of our critical prehistorical checks.

We took material from a forest in Wisconsin which had been pushed over by a southward-moving glacier. We measured tree trunks, we measured the soil in which the trees grew, and we measured all parts of the verdure of that forest which had been preserved when the glacier pushed some twenty feet of dirt which covered it. We got the same answer for all of these various parts—11,400 years—to within two or three hundred years.

This had several important messages for us. One was that even the tiniest fibres on the rootlets, if properly cleaned, could be used for reliable dating, because they were of the same dates as the pieces of wood on the big trees. And the humus in the soil was still authentic and reliable.

Then we went to Europe, and in England and northern Germany and northern France found the same dates. Now we have also found limited evidence—but it looks conclusive—in the southern hemisphere.

Another epoch in human history was the advent of man in North, South and Central America. For reasons which are not entirely clear, man came to the Americas after the melting of the last ice sheet. He came 10,400 years ago, and he came at the same time to all three continents.

That is in the sharpest contrast to the European situation. The oldest Englishman is 10,400 years old because he was chased out by the glacier and then the glacier swept all evidence of previous man away. That is why Piltdown worried the life out of us because Piltdown man was presumably much older than 10,400 years, and it was therefore with great comfort that we learned he was a hoax. We contributed a little bit towards discovering the hoax (1). However, the oldest Englishman is 10,400 years old because that's when the ice sheet left England and he was able to walk into England because the Channel was dry. The oldest American is also 10,400 years old.

We can understand why the oldest Englishman is 10,400 years old, but it isn't at all easy to understand why there isn't someone older in the Americas since not all the Americas were glaciated.

(1) In 1912, a skull, jaw and other bone fragments thought to be those of an ancestral human type of the Lower Pleistocene (about 500,000 years ago) were discovered at Piltdown (Sussex), southern England. The reconstructed skull appeared to conflict with all the theories of human evolution held at that time, since it represented a creature with an entirely modern head and a thoroughly ape-like jaw. Some scientists were sceptical, but it was not until 40 years later that fluorine and other tests showed the skull to be not more than 50,000 years old and the jaw that of a modern ape, cunningly faked. Piltdown Man had finally been exposed as an elaborate archaeological fraud.

What men did in Europe was to move to the Mediterranean basin—we have abundant evidence of man around there that goes back way beyond radiocarbon. We have just begun a new dig in Israel, near the Sea of Galilee, which we think is two million years old. That is way beyond radiocarbon, but we are interested in it as we may be able to help in dating the later phases.

After we had dated about a dozen different sites of earliest man, in North America, Central America and South America and obtained 10,400 years for each one, we began to believe that, unlikely as it seems, our findings were true.

As far as I know—with one possible exception—all the earliest man sites in all the three Americas are 10,000 years old, within the error of measurement. This gives us a consistency check as well as a new result in human history.

We could rationalize it and say that for reasons unknown to us, man didn't come to the Americas until the Behring Strait was laid bare by the drop in sea level resulting from the glacial formation in the last Ice Age. The amount of ice was such that the sea level throughout the world fell by 150 feet. If the ocean level drops by 150 feet, a wide stretch is dry between Siberia and Alaska and down the west coast of Alaska and then as far as the State of Washington. It goes pretty far out into the ocean.

We have never been able to find 10,400 year-old men in Alaska itself. This also fits, for the simple reason that the area was covered in ice. Man didn't come through Alaska. He walked across the Behring Strait and then he came down the coast which is now submerged, and his trail is now 150

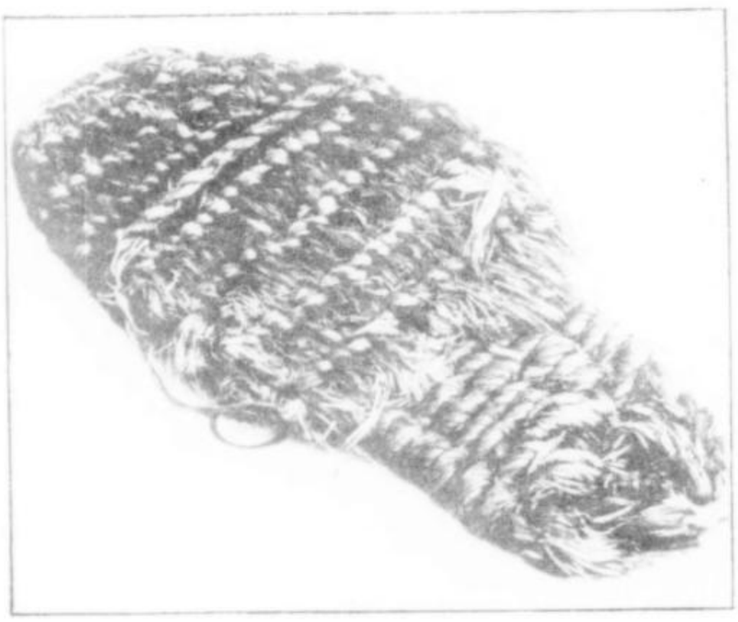


Photo © Willard F. Libby

PREHISTORIC SHOE SHOP

About 20 years ago, a cache of 300 pairs of rope sandals like this one were found neatly stacked in a cave in Oregon, U.S.A. Carbon-14 dated them as 9,000 years old. They had been woven by the prehistoric inhabitants of North America who are thought to have arrived on the continent 1,400 years earlier, after having crossed the Behring Strait, laid bare by the drop in sea level resulting from glacial formation in the last Ice Age, since all the prehistoric sites in the Americas have been dated by carbon-14 at 10,400 years.

feet under water. Then he came inland to about the State of Washington and he moved south, and we found him at the southern tip of South America. Our most recent date was in the highest level of the Peruvian Andes at the 10,400 date.

Other consistency checks include the measurements of various cultures that the archeologists may not be precisely able to date, although they can pick out certain cultural characteristics of a given period. I might mention one or two. Our 10,400 man was a very sophisticated person in some ways. He was a six-footer. He wore clothes the size of those that we would wear and, as I have said, he covered the three continents of the Americas within the measurement of error of radiocarbon—that is within a couple of centuries.

WE were fortunate in finding a most remarkable cache in eastern Oregon (U.S.A.). A road was being dug there in the late 1940s, and an archeologist at the University of Oregon, Dr. Cressman, happened to warn the foreman of this particular road crew to be on the look-out—he knew that they were going to make a deep cut in a pumice deposit of Mount Newbury.

One day, the foreman called Dr. Cressman to tell him that he had found something. And in a cave which was apparently accidentally covered with pumice—like the pumice that preserved Pompeii—was found a collection of marvellously artistically woven sandals, which we date at over 9,000 years.

We have actually succeeded in collecting a few samples from other sites; we had one in 1965 which we dated at 8,500 years. These are the shoes that our prehistoric man wore. In the cave which Dr. Cressman and his crewmen found, were three hundred pairs of these shoes, neatly stacked. A shoe store!

We were very lucky in this research, which dates from before the radiocarbon dating method was invented. Dr. Cressman took his glue pot to lacquer these shoes but he ran out of glue. The glue ruined the shoes for radiocarbon dating, but there were six pairs which he didn't shellac and we got those for dating.

We found the body of a prehistoric man on Santa Rosa Island, off the coast of California, a few years ago. Why these men, of such ability, did not write is an amazing enigma. It is hard to imagine that they were not intelligent enough. The Lascaux caves in central France, as is well known, have been dated at 15,000 years, so

CONTINUED ON NEXT PAGE

Tartaria tablet
Romania (6 cm.)

Jemdet Nasr tablet (Sumer)

Photo © Ashmolean Museum, Oxford

THE ENIGMA OF THE TARTARIA TABLETS

Dating by carbon-14 of three inscribed tablets found in Romania has created a disturbing enigma for archaeologists, who have long accepted as an exact and scientifically established fact that writing was invented in western Asia. The earliest known examples of writing were incised on clay tablets uncovered at Uruk, a Sumerian city that flourished in Mesopotamia during that region's early Bronze Age, and known as the Jemdet Nasr tablets, from the site of their discovery. These tablets are known to be a little over 5,000 years old, and the writing on them, part ideographic, part pictographic, later evolved into the cuneiform system of writing of which numerous examples have been unearthed on tablets of clay and stone.

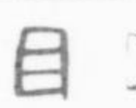
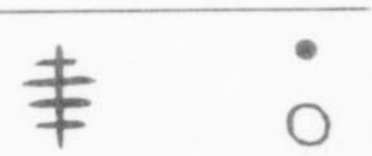
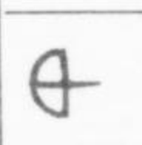
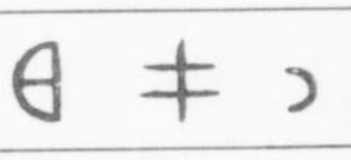
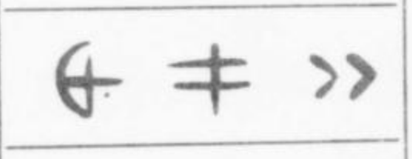
Archaeologists and historians concur on the idea that, in the western world, writing spread from east to west. But in 1961 they were shaken when three small inscribed tablets were unearthed from the remains of a Neolithic village at Tartaria, in the Transylvanian region of Romania. Not only did some of the signs appear to be almost identical with Sumerian ones of 3000 B.C., but in addition the tablets looked much like written records produced in Crete around 2000 B.C. The idea that here was additional proof of writing's spread from east to west was soon dispelled when the ash-filled pit in which the tablets were found was dated by the carbon-14 method. From this analysis, the tablets appeared to be 6,000 years old, a thousand years older in fact than the oldest Sumerian ones.

Could writing have been invented, not in the urban and highly developed civilization of Sumer, but in a rural European culture only just emerging from the stone age? Scientists found this hard to believe, particularly as the Tartaria tablets were the unique vestiges of a culture which apparently vanished thousands of years ago.

A number of theories have been advanced to explain this discovery that seemed to challenge all previous concepts of the birth of writing. Some archaeologists, while not doubting the scientific principles of carbon-14 dating, suggested that the method still involves a considerable margin of error due to factors that are not yet understood. Another theory, advanced by a Czech archaeologist, was that the geological strata at Tartaria might have been disturbed by underground movements, and that the tablets are not as old as the stratum they were found in shows.

If rejuvenated in this way, by some 1,500 to 2,000 years, the Tartaria tablets would no longer challenge Sumer for the fame of having invented writing. But it still remains to be shown how inscribed tablets came to be hidden in a remote part of Europe. Their existence may be linked with the extensive trade routes that stretched in Neolithic times between Europe and western Asia and were used by merchants dealing in gold and the volcanic glass obsidian of which Transylvania had rich deposits. Syrian merchants notably were active in spreading knowledge of pottery and other craft techniques and in establishing cultural contacts. As intermediaries between Sumer and Crete, they ventured deep into Europe by way of the Danube. Perhaps they carried a form of writing to the peoples of Transylvania. But it is not yet clear whether the Tartaria inscriptions were actually writing or simply served as conventional signs (as, for instance, the owner's marks found on ancient pottery), or again whether or not they had a religious or magical connotation. In any event, the enigma of Tartaria remains and is likely to occupy the world's archaeologists for years to come.

Comparison of Sumerian signs (left) and Cretan (centre) with marks on Tartaria tablets (right)

DJEMDET NASR	CNOSSOS	TARTARIA
		
		
		

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Ice Age casts a chill on Carbon-14

we have proof that beautiful paintings were executed five thousand years before our 10,400 man came along.

To me it is quite clear that these people were as intelligent as modern man. Maybe they did write. Maybe we just haven't found the evidence. But in any case they have left these remarkable works.

In the prehistoric Paleolithic Era there are many fine ancient monuments of unknown age and history—even in Egypt. We did pre-dynastic work in Egypt and went back as far as 6,500 years in a fairly continuous record. We worked with Dr. Caton Thompson, of Cambridge, who furnished us with some remarkable samples of ancient Egyptian grain which she had found in granaries in the hills surrounding the Nile valley.

The granaries were filled by farmers nearly 1,500 years before the first dynasty, and they still had grain in them when she came upon them 50 years or so ago. They were holes dug in the top of the hills and lined with straw; the grain was put in and then covered. We dated that grain.

In England, there is a continuous unbroken record going back to 10,400 man. Some of the sites are truly remarkable, as for example, the Star Carr site excavated by Professor Graham Clarke, at Cambridge, and dated at nearly 8,000 years.

EVEN in the historic period, there are known sites in lots of areas, such as the Americas. But we had no written records at all in the Americas, apart from the Mayas. This leaves only the circumstantial records and about all we have for dating in many parts of America is radiocarbon. It fits reasonably into the sociological evidence of pottery and things like this, and we are thus building up a story in the Americas.

But the point is that even in the historic period of the last 4,000 years, radiocarbon does have applications in various parts of the world, as it does for the prehistoric periods; it is essentially all we have in absolute dating.

This question of absoluteness is a difficult one. It isn't possible to say unequivocally that radiocarbon dates are correct. It is possible, I think, to say that in the last 3,700 years, a radiocarbon date is probably accurate to within one or two per cent.

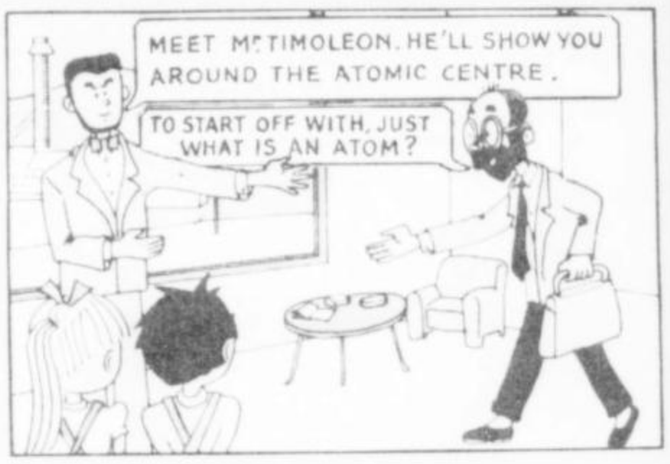
In the prehistoric periods, we simply have to hope that we can develop some auxiliary check to show whether the variation of the solar magnetic field is substantial. We already have considerable evidence in that the first dynasty of Egypt agrees pretty well. There is a tendency for the first dynasty dates to be different from the historical dates, and the difference is such that Dr. Suess's conjecture might fit. His conjecture—and he himself insists that it is conjecture, because he is extrapolating—is, in effect: "If you had a really cold period, then it would be an Ice Age, and then the radiocarbon dates would be different and so we must correct the radiocarbon dates by maybe as much as 2,000 years at 11,000."

This is about the biggest catastrophe that we can imagine at the moment happening to radiocarbon dates. In the 4,000 most recent years, they are probably good to a couple of centuries. When they are calibrated in the last 2,000 years, they are probably as accurate as we can measure.

There are more questions in the measurement than just the counting error; there are problems like the tree rings. If we take a piece of wood, we find it has various rings and each year has its own radiocarbon in it. We have to determine very carefully how many rings there are and whether the wood came from the inside or the outer part of the trunk.

We find in the old English houses, for example, that there is considerable evidence of the re-use of major timbers. In the pyramid at Teotihuacan near Mexico City, we have positive proof that timbers were used in the central structures which were several hundred years old when the pyramid was built. Things like this have to be taken into account.

We have been re-investigating the 12 first dynasties of Egypt with the help of the British Museum for that very reason. All the graves of early Egypt were robbed and therefore there is a serious question of authenticity in any moveable material. We have recently developed a technique of removing protein from bone and dating it. We are going to do this on the mummies as we think it is very unlikely that any grave robber would have stolen them and later replaced them.



SOPHIE and BRUNO in the land of the Atom

On the following pages, the "Unesco Courier" is pleased to publish a condensation from a comic book, "Sophie and Bruno in the Land of the Atom", published several years ago by the French Commissariat of Atomic Energy, in Paris, and illustrated by Jacques Castan (1).

In simple everyday terms and amusing drawings the book tells of a visit to a nuclear power station by Sophie and Bruno, and their initiation into the world within the atom and of some of the peaceful uses of atomic energy. We are sure our young and older readers alike will take pleasure in joining the two youngsters on their journey.

(1) "Sophie and Bruno in the Land of the Atom" was not produced for public sale, and is now out of print. The book was originally published in colour.

AN ATOM...ER... THAT'S THE SMALLEST PART OF AN ELEMENT...ER...CONTAINING ALL THE PROPERTIES OF THAT ELEMENT...ER...THE ATOM IS INDIVISIBLE.

RUBBISH!...IF THE ATOM WERE INDIVISIBLE THIS ATOMIC CENTRE WOULDN'T EXIST!

electron
Nucleus of atom (protons + neutrons)
electron
● PROTONS
○ NEUTRONS
the electrons whirl around the nucleus

HERE'S AN ATOM AS WE CAN IMAGINE IT LOOKS. THERE IS AN INFINITELY TINY NUCLEUS MADE UP OF PROTONS AND NEUTRONS. EVEN TINIER ELECTRONS WHIRL AROUND THIS NUCLEUS LIKE PLANETS AROUND THE SUN. THE SPACE BETWEEN THE ELECTRONS AND THE NUCLEUS MAY SEEM INSIGNIFICANTLY SMALL TO US BUT ON THE ATOMIC SCALE IT IS FANTASTICALLY LARGE, THE ATOM'S DIAMETER BEING ABOUT 20,000 TIMES GREATER THAN THE NUCLEUS. THE INSIDE OF THE ATOM, THEN, IS MOSTLY EMPTY SPACE!

THE LIGHTEST ATOM IS THE HYDROGEN ATOM. IT IS COMPOSED OF JUST ONE PROTON AND ONE ELECTRON. HERE IT IS ON THE LEFT. ONE OF THE HEAVIEST ATOMS IS THE URANIUM ATOM WITH A NUCLEUS OF 92 PROTONS AND 143 NEUTRONS. 92 ELECTRONS MOVE ROUND THE NUCLEUS – AS MANY ELECTRONS AS PROTONS...

1 PROTON
1 ELECTRON
hydrogen atom

92 PROTONS
143 NEUTRONS
92 ELECTRONS
uranium atom

URANIUM, LIKE MANY OTHER ELEMENTS, IS NATURALLY RADIOACTIVE. IT DISINTEGRATES AND CHANGES IMPERCEPTIBLY WHILE EMITTING RADIATIONS.

HER'S A PIECE OF NATURAL URANIUM.

DON'T BE SCARED! GO AHEAD & TOUCH IT. THIS URANIUM HASN'T BEEN IN A REACTOR. ITS RADIOACTIVITY IS VERY VERY LOW!

JUST WHAT IS A REACTOR?

HOLD YOUR HORSES!! YOU'LL SEE.

URANIUM ATOMS EMIT MANY FORMS OF RADIATION. BUT ONE IS OF SPECIAL INTEREST TO US HERE...

...I MEAN THE RADIATION FROM NEUTRONS. EVERY SO OFTEN, A NEUTRON ESCAPES FROM THE URANIUM NUCLEUS...

FLAP

...EVERYTHING WE DO IN THIS CENTRE IS BASED ON THIS PHENOMENON.

IN AN ATOMIC REACTOR URANIUM IS PRESENT IN LARGE QUANTITIES. WHEN A URANIUM ATOM EMITS NEUTRONS, THE NEUTRONS COLLIDE WITH OTHER URANIUM ATOMS AND SPLIT THEM APART, RELEASING VAST SOURCES OF ENERGY. OTHER NEUTRONS DO THE SAME, STARTING A CHAIN REACTION. FOLLOW ME?

THAT'S HOW THE ATOM BOMB WORKS! ONE AFTER THE OTHER ALL THE ATOMS DISINTEGRATE!...

IT'S THE EXPLOSION!

OZING! FLAP!

IN AN ATOMIC REACTOR, THE DISINTEGRATION IS CONTROLLED AND THE HEAT RELEASED BY SPLITTING THE ATOMIC NUCLEI IS RECUPERATED. LET'S GO IN AND TAKE A LOOK AT CLOSE RANGE...

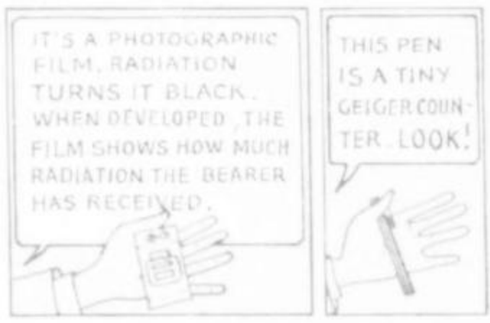
HEE! HEE!

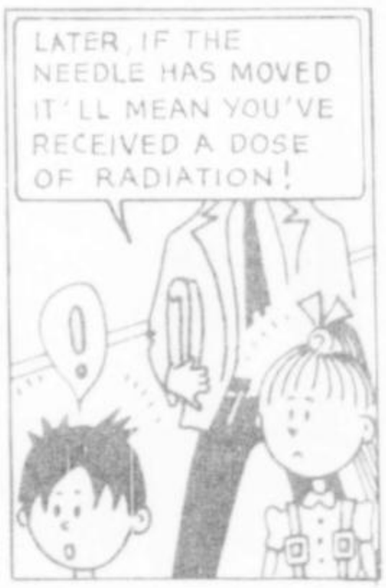
BOINK!

LET'S START OUR VISIT.

CONTINUED ON NEXT PAGE

THE AIR HEATS UP AS IT PASSES IN THE REACTOR AND IS CHANNELLED TO A RECUPERATOR WHERE THE HEAT IS TRANSFERRED TO PRESSURIZED WATER. THE WATER IS VAPOURIZED IN A TURBINE WHICH OPERATES A DYNAMO.
THE DYNAMO, AS YOU KNOW, PRODUCES ELECTRICITY. THE AIR IS THEN FILTERED AND EVACUATED BY THE CHIMNEY OVER THERE, 100 METRES HIGH.


IT'S A PHOTOGRAPHIC FILM. RADIATION TURNS IT BLACK. WHEN DEVELOPED, THE FILM SHOWS HOW MUCH RADIATION THE BEARER HAS RECEIVED.
THIS PEN IS A TINY GEIGER COUNTER. LOOK!



...HERE WE ARE BEFORE ONE OF OUR REACTORS OR PILES.
THE BUILDING THAT HOUSES IT COVERS A SURFACE OF 2,000 sq. METRES AND IS 34 METRES HIGH.
THE CONCRETE SHIELD SURROUNDING THE BLOCK PROTECTS US FROM THE RADIATIONS, AND IS 20 METRES HIGH. THE ROUND HOLES YOU SEE (1,337 IN ALL) ARE TUBES GOING THROUGH THE REACTOR. EACH TUBE CONTAINS 2 URANIUM RODS 3.80 METRES LONG IN AN INSULATED MAGNESIUM CASING. THE TUBES RUN THROUGH A GRAPHITE STACK. THE REACTOR CONTAINS 1,400 TONS OF GRAPHITE AND 100 TONS OF URANIUM...

NOTE THAT THE STAFF WEAR NO SPECIAL PROTECTIVE EQUIPMENT TO GO ABOUT THEIR BUSINESS.

HEY, MR TIMOLEON WHATD'YA NEED ALL THAT GRAPHITE FOR?

REMEMBER WHAT I SAID ABOUT HOW A CHAIN REACTION WORKS? THE URANIUM ATOM EMITS A NEUTRON...

... THE NEUTRON SPLITS AN ATOM, THE NEUTRONS IN THE SPLIT ATOM IN TURN ETC. ETC... ETC...

BRAVO!

BUT THE NEUTRONS ARE EMITTED AT VERY HIGH VELOCITY. AS ATOMS ARE INFINITELY TINY, THERE IS VERY LITTLE CHANCE OF A NEUTRON HITTING AN ATOM AND SPLITTING IT.

WE CAN INCREASE THE CHANCES IF WE TAKE ADVANTAGE OF THE NATURAL ATTRACTION OF ATOMS. YOU'VE HEARD ABOUT THE EARTH'S GRAVITATION ATTRACTION OR THAT OF THE MOON AND OTHER PLANETS, ETC ...zzz

WELL, IT'S ALMOST THE SAME THING WITH ATOMS. THEY ATTRACT NEUTRONS IF THE NEUTRONS ARE NOT MOVING TOO FAST. THAT'S WHERE GRAPHITE COMES IN...

GRAPHITE SLOWS DOWN THE NEUTRONS AND DEFLECTS THEM TOWARDS THE URANIUM RODS...

ER... I SAY... MR TIMOLEON CAN A REACTOR ...ER... EXPLODE?

NO! IT CAN'T! THE INSIDE OF A REACTOR HAS VERTICAL WALLS IN WHICH BORON CONTROL RODS MOVE UP AND DOWN.

BORON "EATS" UP" NEUTRONS - IF I CAN PUT IT THAT WAY...

WHEN THE RODS DESCEND, THE BORON ABSORBS THE NEUTRONS, AND THE REACTOR STOPS...

TO START THE REACTOR, WE JUST WIND THE BORON RODS UP AGAIN. NOTHING MORE TO IT!

IF ANYTHING GOES WRONG - SAY A MAGNESIUM CASING BREAKS OR THE AIR CIRCULATION STOPS, OR THE ELECTRICITY FAILS - THE SAFETY RODS DROP DOWN AUTOMATICALLY, AND THE REACTOR STOPS!

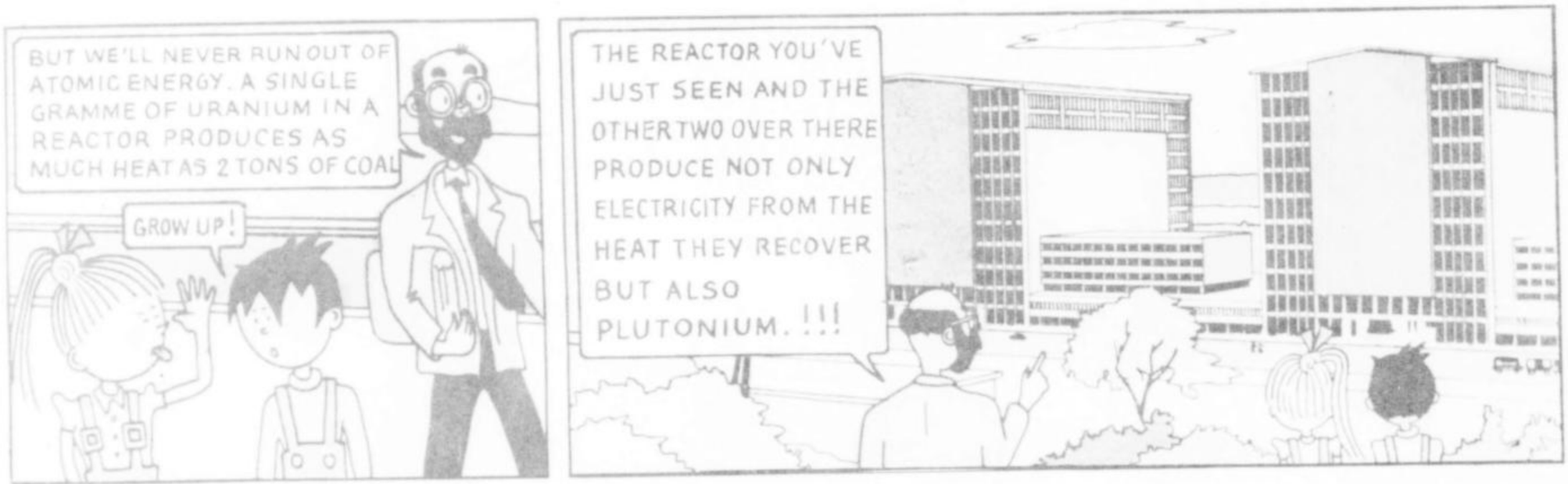
BRUNO, SOPHIE, HERE'S THE REACTOR CONTROL ROOM.

THIS IS A REACTOR'S BRAIN IT MEASURES THE TEMPERATURE, OF THE GRAPHITE, CONCRETE AND AIR, & THE FLUX OF NEUTRONS. THE 4 CONTROL RODS AND THE 32 SAFETY RODS ARE OPERATED FROM HERE. LOOK BUT DON'T TOUCH ANYTHING!

COUTINUED ON NEXT PAGE

WELL, WHAT DID THE TWO OF YOU THINK OF THE PLACE'?
BOY, I WAS GLAD THAT GEIGER NEEDLE DIDN'T BUDGE!
GOSH, THE CENTRE'S BIG! BUT WHAT'S IT USED FOR?
TO MAKE ELECTRI-CITY, THAT'S WHAT!
HEE! HEE! WHAT A LAUGH! ALL THAT JUST TO MAKE ELECTRICITY!

WHEN IT'S SO SIMPLE TO MAKE IT WITH WATER!
WITH WATER ???
WHAT ABOUT DAMS, SILLY!
NOT BAD, NOT BAD, SOPHIE!
BUT SOPHIE'S OVERLOOKED ONE THING. WATER'S GETTING SCARCER EVERY DAY. ANOTHER THING, THE WORLD NOW NEEDS SO MUCH ELECTRIC POWER THAT SOON OUR WATER, OIL AND COAL RESOURCES WILL BE EXHAUSTED. DID YOU KNOW THAT THE WORLD'S USED UP MORE POWER IN THE LAST 50 YEARS THAN IN ALL ITS HISTORY!


BUT WE'LL NEVER RUN OUT OF ATOMIC ENERGY. A SINGLE GRAMME OF URANIUM IN A REACTOR PRODUCES AS MUCH HEAT AS 2 TONS OF COAL
GROW UP!
THE REACTOR YOU'VE JUST SEEN AND THE OTHER TWO OVER THERE PRODUCE NOT ONLY ELECTRICITY FROM THE HEAT THEY RECOVER BUT ALSO PLUTONIUM. !!!

PULL-TONY-IN?? WHAT'S THAT?
SO FAR I'VE ONLY TOLD YOU ABOUT ATOMIC REACTORS AS A HEAT-PRODUCING CONTRIVANCE...
NOW LET'S BUILD OUR OWN LITTLE REACTOR...
THESE TWIGS WILL MAKE VERY GOOD URANIUM BARS, INDEED...

THE REACTOR IS NOW READY TO GO!

THE CHAIN REACTION HAS STARTED...!

LET'S PUSH DOWN THE RODS...!

PART OF THE WOOD IS GONE. IT'S BEEN USED UP AS FUEL.

...IN A REACTOR IT'S ALMOST THE SAME: PART OF THE URANIUM DISINTEGRATES AND FEEDS THE CHAIN REACTION.

SOME OF THE WOOD HAS NOT BEEN ENTIRELY CONSUMED... SOME ASHES ARE LEFT.

IN AN ATOMIC PILE, PART OF THE URANIUM IS TRANSFORMED INTO FISSION PRODUCTS. THESE FISSION PRODUCTS ARE NOTHING MORE THAN THE ASHES OF THE REACTOR!

SO YOU SEE, PART OF THE URANIUM HAS VANISHED; ANOTHER PART HAS LEFT... WASTE PRODUCTS...

...FISSION PRODUCTS, OF COURSE!

...AND A THIRD PART...

A THIRD PART OF THE URANIUM HAS CHANGED INTO... PLUTONIUM!

FISSION PRODUCTS CLOG THE PIPE...OOPS!! I MEAN...THE REACTOR!! JUST AS SOOT AND ASHES CLOG UP A COAL STOVE...

BUT PLUTONIUM IS DIFFERENT, YOU SEE, IT CAN BE USED AS A FUEL BY ITSELF...

IT'S JUST AS IF OUR FIRE HAD ACTUALLY PRODUCED... WOOD IN THE PROCESS OF BURNING IT!

GOSH!

...LUCKY KIDS!... YOU CAN SEE THINGS...

...I NEVER DARED DREAM OF AT YOUR AGE!

YOU DON'T KNOW HOW LUCKY YOU ARE! SCIENTISTS ARE PERFECTING NEW REACTORS THAT WILL...

...PRODUCE MORE FUEL THAN THEY CONSUME...

TO HELP YOU UNDERSTAND WHAT GOES ON IN A REACTOR, I LIT A FIRE OF TWIGS. BUT OF COURSE THERE'S NO FIRE AND NO ASHES IN A REACTOR. EVERYTHING IS ON THE ATOMIC SCALE. THE URANIUM RODS IN THEIR CASINGS SEEM TO BE UNCHANGED, BUT IF YOU EXAMINE THEM CAREFULLY YOU'LL BE ABLE TO SEE THAT THEY HAVE UNDERGONE DEFINITE TRANSFORMATION...

...THE RODS NO LONGER CONTAIN ONLY URANIUM. PLUTONIUM AND OTHER FISSION PRODUCTS ARE ALSO PRESENT PLUTONIUM IS PRECIOUS AND HAS TO BE SEPARATED FROM THESE OTHER PRODUCTS. THIS IS DONE IN THE LARGE FACTORY YOU SEE OVER THERE.

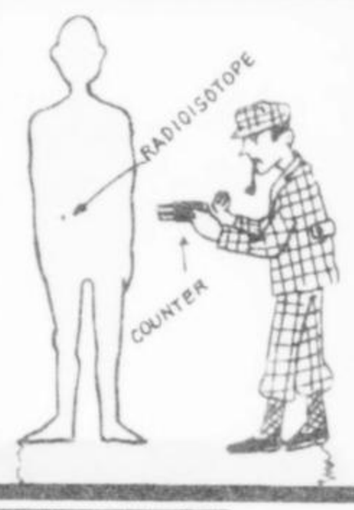
CONTINUED ON NEXT PAGE

RADIOISOTOPES AND SOME OF THEIR USES:

IN MEDICINE:

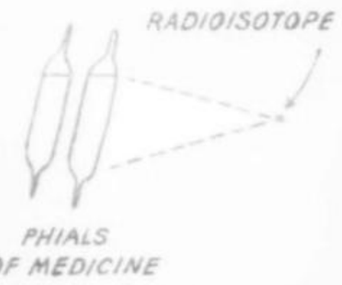
RADIOACTIVE COBALT IS USED INSTEAD OF RADIUM *(WHICH IS BOTH RARE AND EXPENSIVE)* IN THE TREATMENT OF CANCER

RADIOISOTOPES, KNOWN AS TRACERS CAN BE INJECTED INTO THE BODY IN MINUTE, HARMLESS QUANTITIES THE RADIATION TRIGGERS A COUNTER DEVICE AND PERMITS THE STUDY OF THE FUNCTIONING OF THE BLOOD & OF THE BODY'S ORGANS.



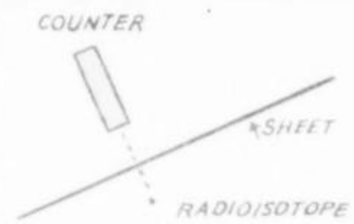
STRONG RADIATION KILLS MICROBES

STERILIZATION OF MEDICINES



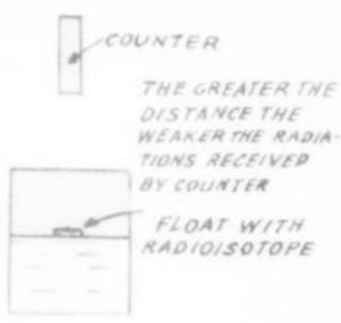
IN INDUSTRY:

MEASURING AND REGULATING THICKNESS OF SHEETS OF CARDBOARD, PLASTIC, GLASS, ETC.



STRENGTH OF RADIATION RECEIVED BY COUNTER VARIES ACCORDING TO THICKNESS OF THE SHEET.

CHECKING THE LEVEL OF LIQUIDS IN A CLOSED CONTAINER

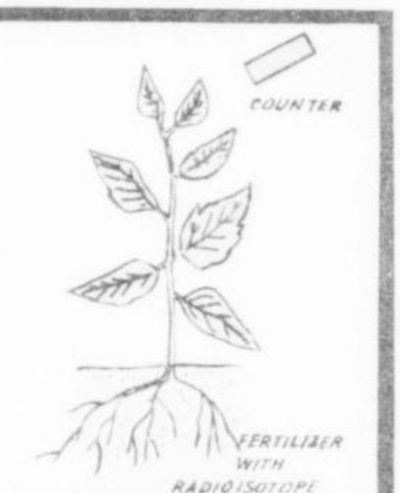


AMOUNT OF RADIATION RECEIVED VARIES WITH LEVEL OF LIQUID.

IN AGRICULTURE:

IMPROVED USE OF FERTILIZERS

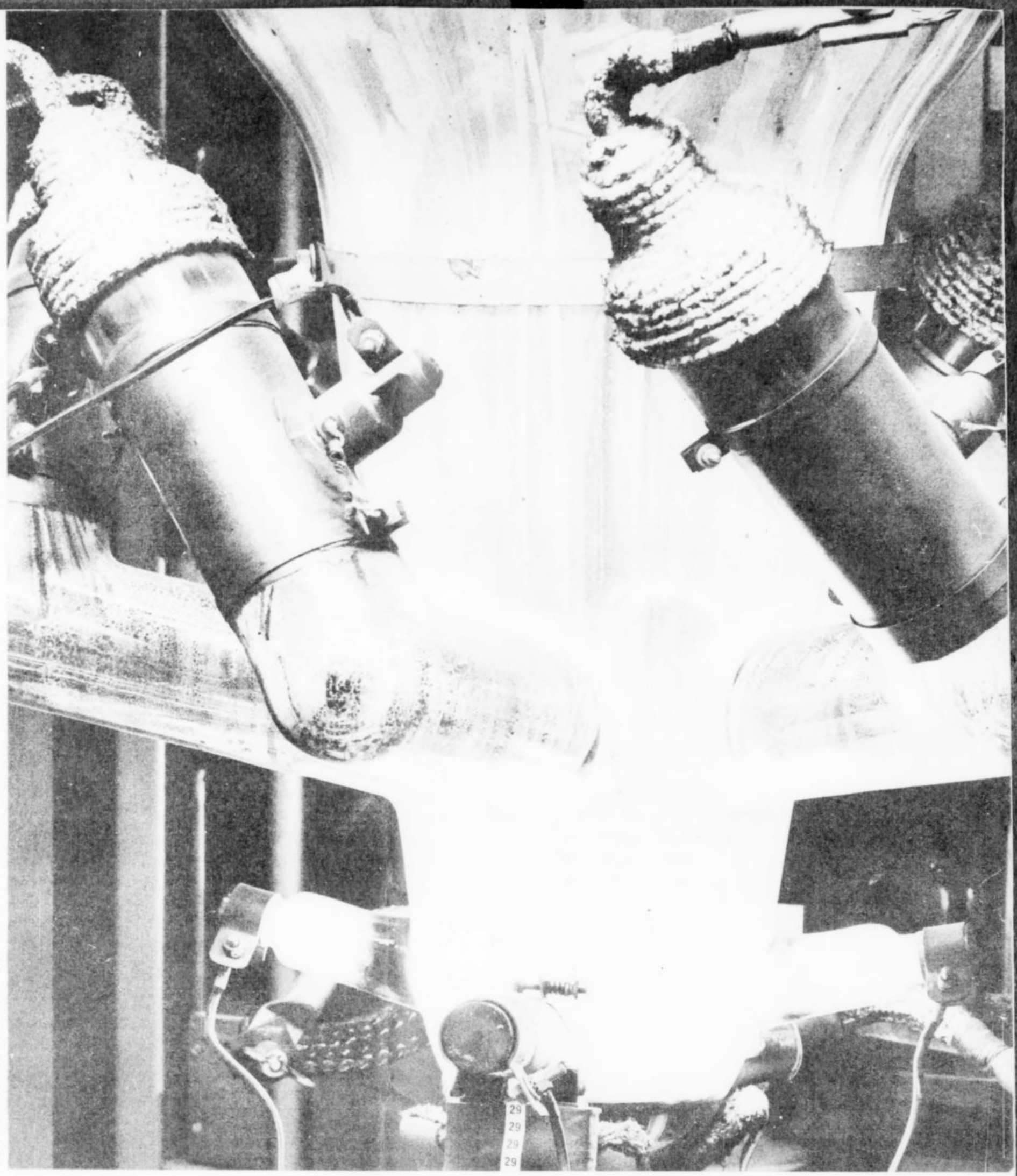
RADIOISOTOPE IS ADDED TO FERTILIZER. ITS ACTION INSIDE PLANT CAN BE TRACED WITH PRECISION.



IRRADIATED SEEDS PRODUCE BETTER PLANTS

FOOD PRESERVATION BY IRRADIATION

RADIATION-PROCESSED POTATOES DO NOT SPROUT



The transmutation of matter—once the dream of every alchemist of antiquity—is now an everyday occurrence thanks to the powerful accelerators built by atomic scientists to bombard atoms with enormous bursts of energy. Such experiments have made possible the discovery of hitherto unknown elements. Strange-looking "horned" apparatus shown here supplies electric current to one of these giant nuclear research accelerators, a synchrotron.

Photo © Jean-Pierre Sudre, Paris

THE TWILIGHT LIVES OF MAN-MADE ATOMS

by Georgi Flerov and Vladimir Kuznetsov

GEORGI NICOLAEVICH FLEROV *is director of the Laboratory of Nuclear Reactions of the Nuclear Research Institute, at Dubna, U.S.S.R., and a corresponding member of the Academy of Sciences of the U.S.S.R. He is co-discoverer of the phenomenon of spontaneous fission of heavy nuclei (with K. Petrzhak). He directed the research team which synthesized and studied elements 102, 103 and 104, and whose continuing research is devoted to the synthesis and study of new trans-uranium elements and isotopes.*

VLADIMIR IVANOVICH KUZNETSOV *is chief engineer of the Laboratory of Nuclear Reactions at Dubna, and was one of its first staff members. He was a member of the research team which discovered element 101.*

LIFE on earth evolved through the absorption of nuclear energy. The campfire of primitive man, the coal consumed by blast furnaces, the propellant that drives a space rocket—all these are products of the nuclear energy of solar matter, transmitted to earth by means of sunlight and stored at different times by plants and animals in the form of

CONTINUED ON NEXT PAGE

The reincarnation of 'extinct' nuclei

chemical energy—the energy of the electron clouds of atoms and molecules.

The atomic nucleus, that inexhaustible accumulator of the world's energy, ceased being an indivisible entity only in the twentieth century. The very first investigations of it led to the discovery of vast sources of unheard of power.

The practical applications of nuclear physics are not, of course, restricted to power production. They also comprise investigations of the structure of materials such as metals and alloys, methods of analysis billions of times more sensitive than ever before, and the increasing use of "tracer" atoms in biology, agriculture and metallurgy; nuclear physics has in fact become an essential element in many modern industries.

And yet, for all its applications, our knowledge of the structure of the atomic nucleus is still far from complete. A penetration into its mysteries may well yield much in the most unexpected spheres of science.

Man has long been intrigued by the history of the origin of the earth, the sun, the universe. A reflection of this is the account of the creation of the world with which the Old Testament commences. It would seem that man could hardly hope to draw a definitive picture, or even a general outline, of the beginnings of the world, but nuclear studies in the last few decades have contributed substantially to our knowledge in this field too.

According to present-day conceptions, the chemical elements of the solar system were synthesised out of protons—the nuclei of galactic oxygen. The fundamental bricks of matter, protons and neutrons, yielded a great diversity of agglomerations as a result of the compression of the primordial hydrogen and the resulting nuclear reactions.

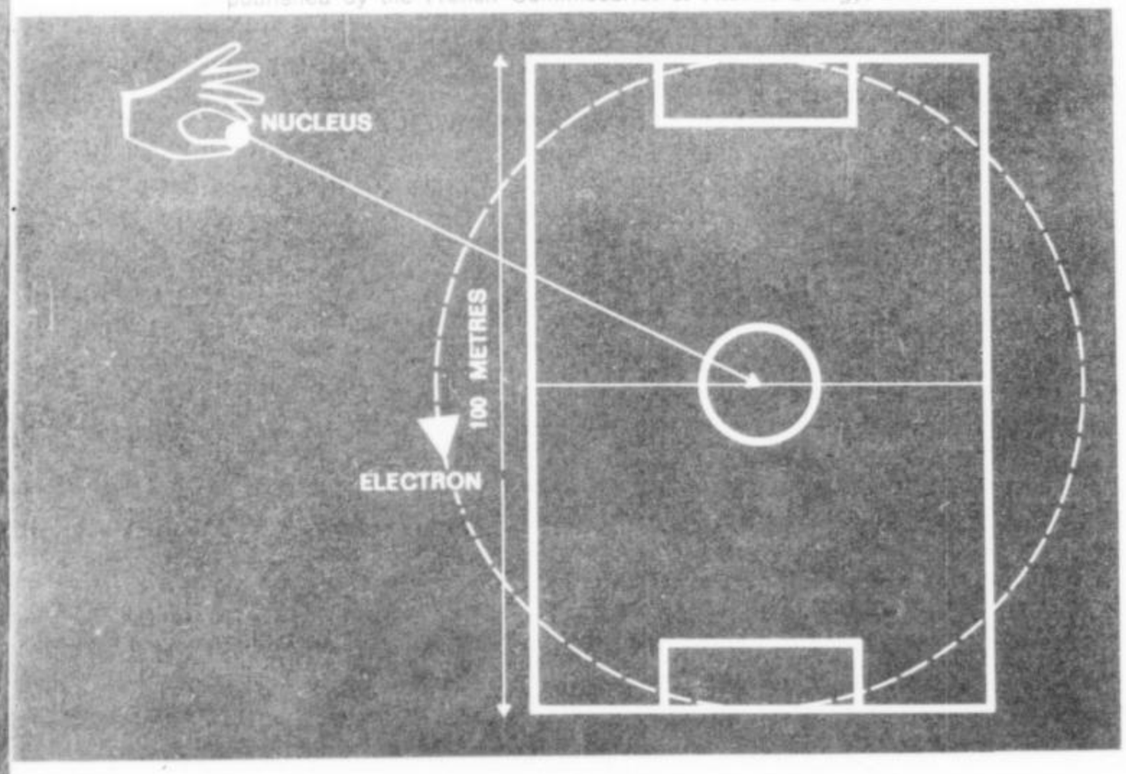
Besides the nuclei of isotopes of the chemical elements which comprise the earth today or which have been synthesized in the laboratory, there were other isotopes and elements now unknown to us (1).

It has been calculated that, theoretically, there are some 5,000 proton-neutron associations that can hold together long enough to allow them to be validly considered as atomic nuclei. Only 1,500 of these have been studied to a greater or lesser extent. The number of isotopes of "natural" nuclei surviving on earth since the birth of the universe, some 5,000 million years ago or more, is no more than 450; the lifetime of all the others is too short for them to have lasted to our day.

One can imagine the sensation that would be caused by the resuscitation of a mammoth or dinosaur in a biological laboratory. Yet physics laboratories all over the world have recreated nuclei that became "extinct" thousands of millions of years before the first dinosaur appeared on earth. So far, some 1,200 have been produced, and some of these isotopes are being manufactured on an industrial scale.

(1) Isotopes are variant forms of one and the same element. All the isotopes of a given element have the same atomic number, that is, the same number of protons in their nuclei, but they have different numbers of neutrons in their nuclei. Isotopes thus differ only in their atomic weight or mass numbers which express the total of both protons and neutrons in the nucleus.

Drawing from "L'Energie Nucléaire", published by the French Commissariat of Atomic Energy, Paris



ATOM AS BIG AS A FOOTBALL FIELD. If an atom were enlarged to the size of a football field, as in diagram left, its nucleus would be no bigger than a marble! The inside of an atom between the nucleus and the electrons in orbit around it is all empty space. In a single drop of water there are 60 million million atoms of hydrogen and 30 million million atoms of oxygen. Electrons whirling around the nucleus, circle it 7,000,000,000,000,000 times a second.

The study and systematization of the properties of synthetic nuclei have provided the fundamental empirical data on which contemporary notions of nuclear structure are based. But the synthesis and study of two or three thousand additional nuclear "dinosaurs" would substantially contribute to our knowledge and conceptions in this important scientific domain, especially as some of the still unsynthesized nuclei possess highly interesting properties—with an excess or shortage of neutrons and with high atomic numbers.

Nuclear matter in such nucleonic associations must be in unusual, "limiting" states, investigation of which usually yields considerable results. We already know that revolutionary changes in scientific thinking have resulted from discoveries made during studies of the behaviour of matter in extreme conditions of temperature and pressure.

Especially dramatic is the history of the discovery of the isotopes of the transuranium elements, that is, isotopes with atomic numbers higher than uranium—number 92 in the Periodic Table (2). None of these isotopes is stable enough for it to have survived till our time.

Of all the synthetic elements the "most important" is plutonium, or rather its isotope with mass number 239, which is capable of sustaining a nuclear chain reaction. In fact, plutonium-239 has proved the most suitable material for nuclear weapons as well as for the peaceful production of nuclear energy.

But though nuclear bombs are today made of plutonium, it would hardly be right to say that the only result of the discovery of this new element was the creation of one more threat to humanity. It is plutonium that opens up the prospects of the peaceful utilization of the energy of heavy nuclei on a substantial scale, since plutonium-239 is derived from uranium-238, the uranium isotope which exists in comparatively abundant quantities, but which cannot be directly used as a nuclear fuel.

The isotope uranium-235, which can

(2) The "table of organization" of the different varieties of atoms, called the chemical elements, of which 104—some natural, others man-made—are now known. The Periodic Table was established in 1869 by the Russian chemist, Dmitri I. Mendeleyev. After studying the chemical and physical properties of the 63 elements known in 1869, Mendeleyev was able to show that these properties tended to repeat themselves in periodic fashion as one went up the scale of atomic weights.

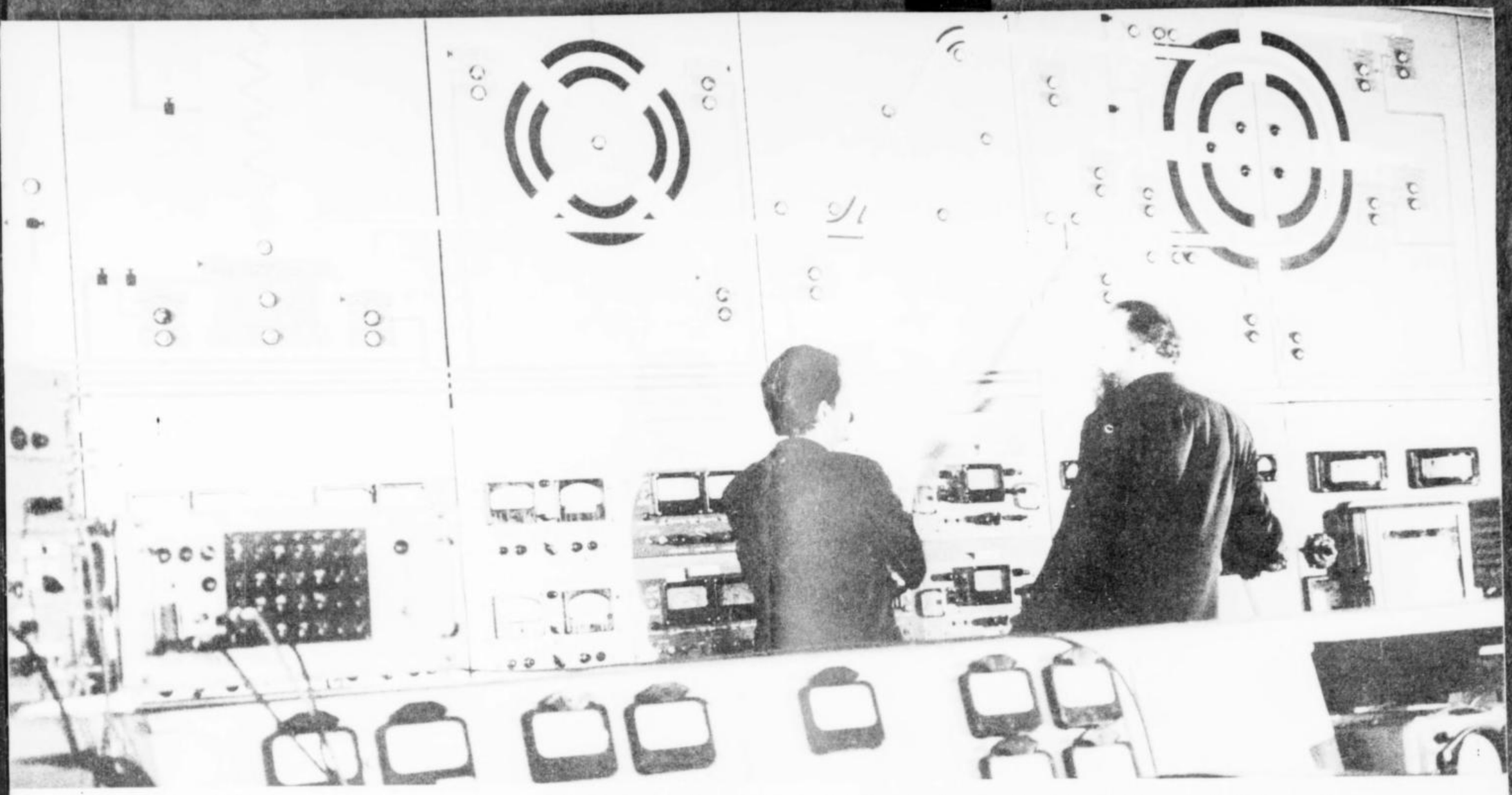


Photo © Paris-Match

ATOM BUSTER. Above the control panel of a synchrotron particle accelerator at the Institute of Nuclear Physics, in Akademgorodok, Siberia (U.S.S.R.), a diagram shows the shape of the "race track," along which scientists boost atomic particles to fantastic speeds (hundreds of thousands of kilometres in a few seconds). The particles then strike atomic nuclei targets and smash them open, releasing their component parts for scientific analysis. Accelerators are like "super microscopes" which permit scientists to see the formerly invisible world within the atom. Increasingly powerful accelerators, now used by scientists on every continent, are vital for peaceful nuclear research (see "Unesco Courier", Mar. 1966).

be directly used in nuclear reactors, exists only in very limited quantities, being 140 times less plentiful than uranium-238. There would simply not be enough uranium-235 for the peaceful uses of the atom.

The energy reserves contained in the nuclei of uranium-238 are sufficient to supply human needs for tens of thousands of years, even allowing for vastly increased demands in the future. Thus, the production of the first synthetic elements and the investigation of their properties may play a decisive role in the extremely important field of providing for the energy needs of mankind.

The elements from numbers 95 to 100, which do not have the practical value of plutonium, have been synthesized. The process of the production of new elements, which is done by subjecting heavy atomic nuclei to high intensity irradiation by neutrons, can to some extent serve as an indication of how heavy elements are naturally synthesized in the universe.

Data thus obtained have served as the basis for postulating many attractive theories of the origin of chemical elements, and nuclear experiments tend to confirm that these hypotheses describe processes not so different from those that actually take place.

Nuclei with atomic numbers of over 100 must be synthesized by the fusion of two complex nuclei. Usually, one of these, the nucleus of the heavy element, is a component of the target bombarded by oxygen, neon or argon nuclei accelerated to one-tenth the velocity of light. Nuclei colliding at such speeds overcome the forces of repulsion existing between them and produce the nucleus of a new element.

The half-life of the isotopes of elements with atomic numbers greater than 100 is very short, and the quantity produced in nuclear reactions is very small. Nevertheless, in 1955, the 101st square in Mendeleyev's Periodic Table was occupied by a new synthetic element produced by a team of American physicists and chemists headed by Glenn Seaborg, which they named mendelevium (in honour of Mendeleyev).

The next step was the synthesis of element 102. Within a year, its discovery was announced in scientific journals. However, the early works abounded in errors, and it was ten more years before the new element was finally identified.

The difficulties of studying element 102 stem from the small half-life of its isotopes, which is at best measured in minutes, and more often lasts seconds or fractions of a second. That is why the traditional chemical method of identifying the element could not be applied.

New methods based on other physical principles were required. They were developed at the Lawrence Radiation Laboratory at Berkley, California, and the Joint Nuclear Research Institute, an international scientific centre of twelve socialist countries located at Dubna on the Volga, not far from Moscow.

It was in the Nuclear Reactions Laboratory at Dubna that in 1966 the first reliable data on the properties of five isotopes of elements 102 were obtained. A year later, the findings were confirmed by American scientists.

Undaunted by the difficulties they had to overcome, the scientists followed up the synthesis of element 102 with elements 103 and 104. Of special scientific value was the investigation of element 104 discovered at the Nuclear Reactions Laboratory and named kurchatovium, after the outstanding Russian physicist, Igor Kurchatov.

In initial experiments, physical methods were used to measure the half-life of one of the isotopes of kurchatovium, which was found to be around 0.5 seconds. In the synthesis, a nucleus of kurchatovium had to be detected amongst thousands of millions of "ballast" nuclei bred in accompanying reactions. This is something like the task one would face if one were given a few moments to locate a particular grain of wheat in a hundred sacks of a 100 kilogrammes each.

Then a method was devised for studying the chemical properties of individual atoms, taking advantage of the very fast chemical reactions that occur in the gaseous state. The development of this method was made

CONTINUED ON NEXT PAGE

The physicist's magic numbers game

easier by the marked difference between the chemical properties of kurchatovium and other transuranium elements.

On an average one nucleus was registered in each six hours of experiments.

The difficulties of studying elements with such high numbers derive both from their very short half-life and from the meagre production of new nuclei. The difficulties increase with the rise in atomic numbers, and after element 106 or 107 they may well prove to be insurmountable by present methods of nuclear physics. Does this mean that the problem of studying elements with high atomic numbers will face an impasse?

Element number 83, bismuth, is followed by polonium, astatine, radon and other isotopes with a very short half-life. Yet isotopes of thorium, uranium and plutonium have much greater half-lives. Following the sharp drop in longevity after bismuth, the half-life of higher elements at first increases (thorium, uranium, plutonium) before decreasing again, with americium, curium, . . . nobelium (102), lawrencium (103), kurchatovium (104), . . . Perhaps there will be a new rise. Perhaps durable elements with atomic numbers above the hundred mark do exist.

EARLY in the 1930s, at the dawn of nuclear physics, a strange periodicity was observed: atomic nuclei in which the numbers of protons or neutrons are 2, 8, 20, 28, 50, 82 or 126 are distinguished by their high stability. It was found that the abundance of such elements as tin, with 50 protons in the nucleus, barium, with 82 neutrons, and lead, with 82 protons, is much greater than that of their neighbours in the Periodic Table.

No explanation for this was offered at the time, and physicists began to call these proton or neutron numbers "magic numbers". If the proton or neutron number in a nucleus is a "magic number", that nucleus is unusually stable. A "doubly magic" nucleus is the lead isotope 208, which contains 82 protons and 126 neutrons.

Modern theory has now provided an explanation of the law of "magic numbers". It has been found that, just as the electrons that orbit about the nucleus form electron shells, the nucleons within the atomic nucleus form neutron and proton shells. Their structure is, of course, quite different from those of electron shells. But, as in the case with electron shells, the more stable nuclei are those of isotopes in which the nucleon shells are completely filled.

Theoretically, the 114th and 126th elements should be "super-elements" with closed proton and neutron shells. As "doubly magic" nuclei possess extra stability, in the domain of the 114th and 126th elements there may be isotopes with a relatively long half-life.

We cannot be absolutely sure that the postulated stability will in fact be found to exist. This, however, does not detract from the importance of the quest, for if no new domains of stability exist then it will be necessary to revise many concepts of modern nuclear theory. If, on the other hand, the prediction of stability domains is found to be valid, this will open up new roads for the study of atomic nuclei.

To reach the domain of the 126th element, the atomic number of the target nuclei must be increased by many units, thus bypassing many squares of the Periodic Table. An example of such a reaction which could yield a nucleus of element 126 is the fusion of thorium and krypton nuclei with the emission of several neutrons.

Another possibility is the fusion of two uranium nuclei. The resultant nucleonic structure will be unstable and will decay into nuclear fragments among which the isotopes of elements with a high atomic number may occur.

Reactions like this require heavy nuclei such as uranium to be accelerated to one-tenth the speed of light. In this case, their energy will be sufficient to overcome the electric repulsion forces of the target nuclei and form a super-heavy drop of nuclear matter the disintegration of

ATOMIC BUBBLE BATH. To see what happens inside an atom, scientists place a sort of "nuclear eye" called a bubble chamber to trap high energy particles discharged from an accelerator. Shooting into a superheated liquid, each particle forms a trail of bubbles. In this way, particles whose lives may be as brief as a hundred million million millionths of a second can be photographed for identification and analysis (example seen on cover photo). Bubble chamber shown here is used in laboratory at the European Organization for Nuclear Research in Geneva.

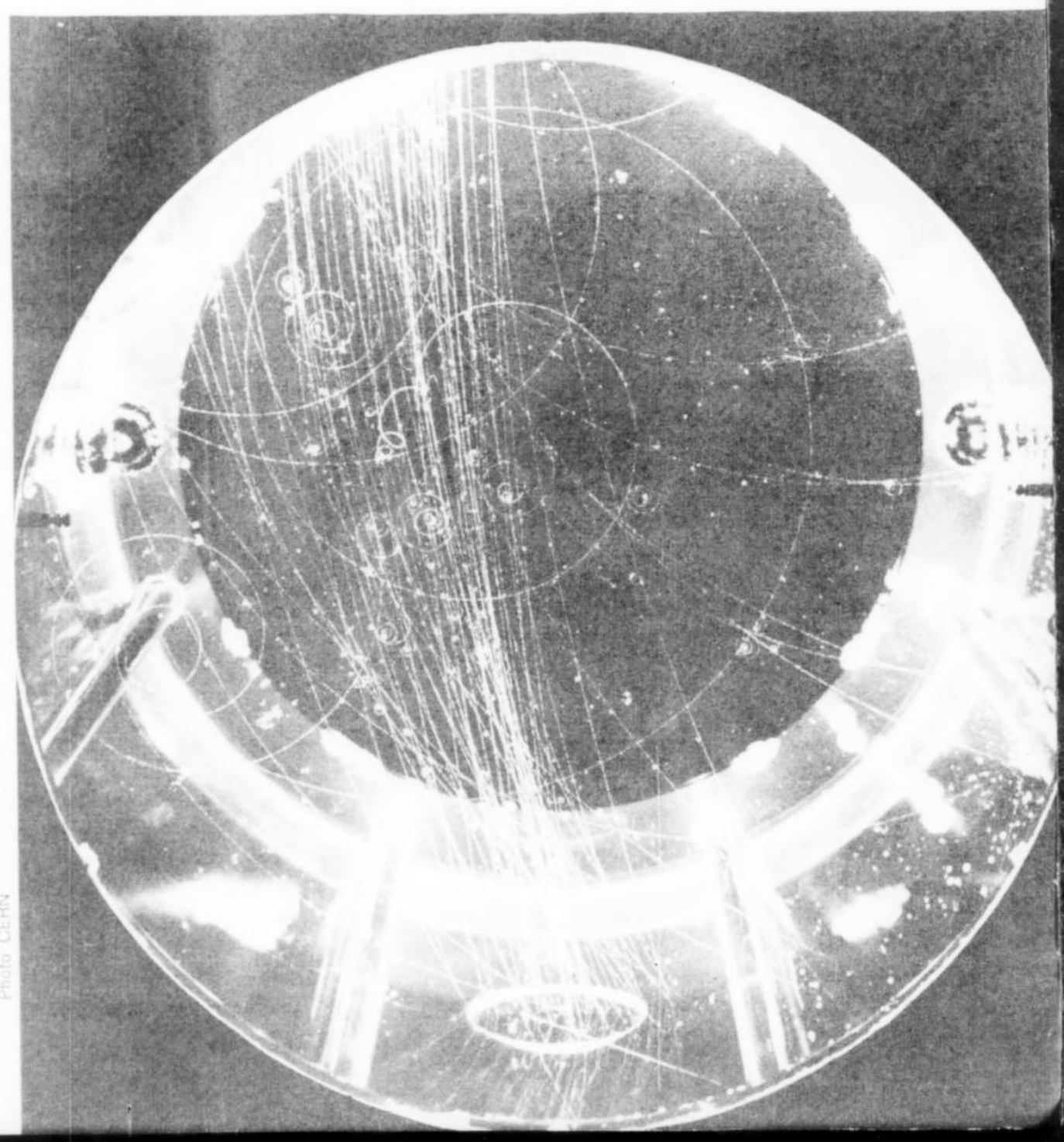


Photo CERN

Photo French Commissariat of Atomic Energy, Paris

MICRO-PORTRAIT. This unusual serrated pattern is a photomicrograph of a fragment of purified uranium. It was photographed through a microscope under polarized light and enlarged 400 times during research into techniques for purifying uranium.

which would result in the appearance of new super-elements. It must be said that technologically this is a quite feasible task which, furthermore, does not call for the heavy capital outlays required for high-energy proton accelerators.

Such projects are being considered in many countries. It is hard to say when the super-elements will be synthesized, but then it is not so long since the synthesis of elements 102 or 104 seemed a fantastic undertaking.

How far can we advance in nuclear synthesis; what are the limits set here by nature?

The nuclei of kurchatovium were detected from the tracks of their fragments produced in spontaneous fission. Incidentally, similar tracks found in components of the earth's crust can provide interesting information about the changes of temperature of rocks at the time when the earth was cooling. These tracks were made by the fragments resulting from the disintegration of the unstable elements which were created at the same time as all other atomic nuclei when the universe originated some thousands of millions of years ago.

The process of spontaneous fission becomes of growing importance with the increase in the atomic numbers of elements, and starting with the 98th element, californium, it is the main type of radioactive decay for many isotopes.

It is this that sets the limit to our advance in studying the higher elements. All nucleonic structures with atomic numbers exceeding 126 must apparently decay so fast as to make it impossible to investigate them, and even if some means is devised, it is hard to designate as an atomic nucleus a drop of nuclear matter that disintegrates in, say, a hundredth of a nanosecond (a nanosecond = one-thousand millionth of a second).

THE methods used for synthesizing and identifying atomic nuclei are employed in solving a great many purely applied problems, such as studying the structure of materials, mineral prospecting, the detection of very low concentrations of substances in mixtures (highly important in the production of semiconductors used in electronic equipment), and the use of "tracer" atoms.

Further prospects of practical applications are connected with the development of methods of synthesizing new elements and isotopes. They will depend fundamentally on the creation of accelerators for nuclei of the heavier elements in the Periodic Table, up to and including thorium and uranium.

In all likelihood, such accelerators will by built in the next few years. This will make it possible to synthesize, within the coming ten or twenty years, three or four thousand new nuclear entities including "super-elements", such as numbers 114 and 126.

Will these studies yield discoveries of an importance comparable to that of the discovery of plutonium? Undoubtedly. The synthesis and study of thousands of isotopes possessing highly significant nuclear properties will enable scientists to gain a deeper understanding of the structure of nuclear matter, and hence, provide broad possibilities for the practical applications of nuclear research.

What destiny awaits the future great discoveries in nuclear physics? This will depend on the men in whose hands they will be placed. Discoveries as such are neither useful nor harmful. It is their utilization that brings ethical problems to the fore. New energies should serve for strengthening the social basis and prosperity of mankind, not for destruction. This is what ethical scientists have always hoped for, scientists who fully realize the value of their research for man, for life on earth.

NUCLEAR ENERGY AND OUR FUTURE

by Glenn T. Seaborg
Nobel Prize, 1951

MAN lives by energy. The more he can put to work, the better he lives. By harnessing energy, he can flick a switch to pump water, start a train, heat a home or light a city.

In the 21st century, most of this energy will come from the nucleus of the atom, and by using it wisely man can improve the way he produces food, uses water and raw materials, handles waste and builds cities.

The need for improvement is evident. By the year 2000, experts predict the earth's population will double. Some expect an eventual population of 15 thousand million people, five times today's total.

But the earth itself will not grow, and to support these extra thousands of millions we must learn to use and reuse our resources with an efficiency we rarely even approach today.

Energy is a resource, and by far the most important contribution the atom will make to the world of tomorrow will result from the combination of very cheap electricity and heat for use in manufacturing processes which it can make possible, particularly with the full development of breeder reactors which create more nuclear fuel than they burn.

One must emphasize that having a large amount of cheap energy is not a panacea in itself. We must develop the technology to take advantage of this energy; it must be applied skilfully, productively and wisely by people who have the tools and training to use it.

Some scientists have considered the concept of using these huge amounts of energy in giant nuclear powered industrial complexes, which we have called "Nuplexes", the energy heart of which would be breeder reactors, with a generating capacity in the multi-million kilowatt range.

A variety of industrial plants coupled to the energy centre would interchange goods and services through a maze of underground arteries, conveyor belts and pipelines.

Iron might be produced by reduction methods. Steel, phosphorus or calcium carbide might be made by electric furnace methods. Other plants might produce aluminium, copper and nitric acid using electrolysis and electrolytic hydrogen. Synthetic materials of all kinds would be produced in still other plants.

If we can develop the sophisticated chemical techniques to capitalize on the cheap power, we might some day be able to completely recycle all our materials and water so that we would have an endless supply of raw materials and a virtually junkless civilization.

It should be emphasized, however, that planning, setting up and successfully operating facilities like this will be a mammoth undertaking requiring great advance study, a massive infusion of capital and, above all, the devotion and hard work of a great many talented people.

Yet the prospects are so great that they have excited the imagination of many of us.

A study conducted last year at the U.S. Atomic Energy Commission's Oak Ridge National Laboratory looked into the possibility of placing nuclear agro-industrial complexes in arid areas such as desert coastal plains.

We know already, for instance, that the economic use of nuclear energy to desalt water is not far off. A large dual purpose nuclear powered electric generating and water desalination plant has been planned for construction in the United States near the city of Los Angeles.

A report on energy centres by the Oak Ridge National Laboratory, which will be available later this year, indicates some exciting prospects for coupling large dual-purpose plants located in coastal desert areas with highly scientific farms or "food factories."

One study in this report considers the energy heart as a huge breeder reactor which could generate 1,000,000 kilowatts of electricty and desalt 400 million gallons of water a day. At the same time, power from the plant could be used to make ammonia fertilizer and phosphorus-bearing fertilizer. It could be that many other by-products from the seawater brine could be produced and used locally or exported.

Electricity from the plant would be used for highly mechanized farming and food processing, as well as to supply light, air-conditioning and power for transport and communications for the personnel operating the complex.

On 200,000 acres, irrigated with the desalted water and fertilized with locally manufactured products, crops would be grown which were specifically bred for the area. Hardly anything would be left to chance or the whims of nature.

Such a food factory could produce a thousand million pounds of grain each year, enough to feed almost 2,500,000 people at a level of 2,400 calories a day. In addition, it could export enough fertilizer to other agricultural areas to cultivate another 10,000,000 acres of land.

IN our concern over the world's food supply we tend to concentrate our thoughts on the production of more food, often forgetting that one-fifth of the world's entire annual food crop is lost or destroyed by pests and spoilage.

By the year 2000, we expect to have largely perfected the techniques of food irradiation so as to greatly reduce such losses. Carefully controlled doses of radiation from certain radioactive isotopes can destroy pests, extend the shelf and storage life of fresh foods and help create new and hardier crop strains.

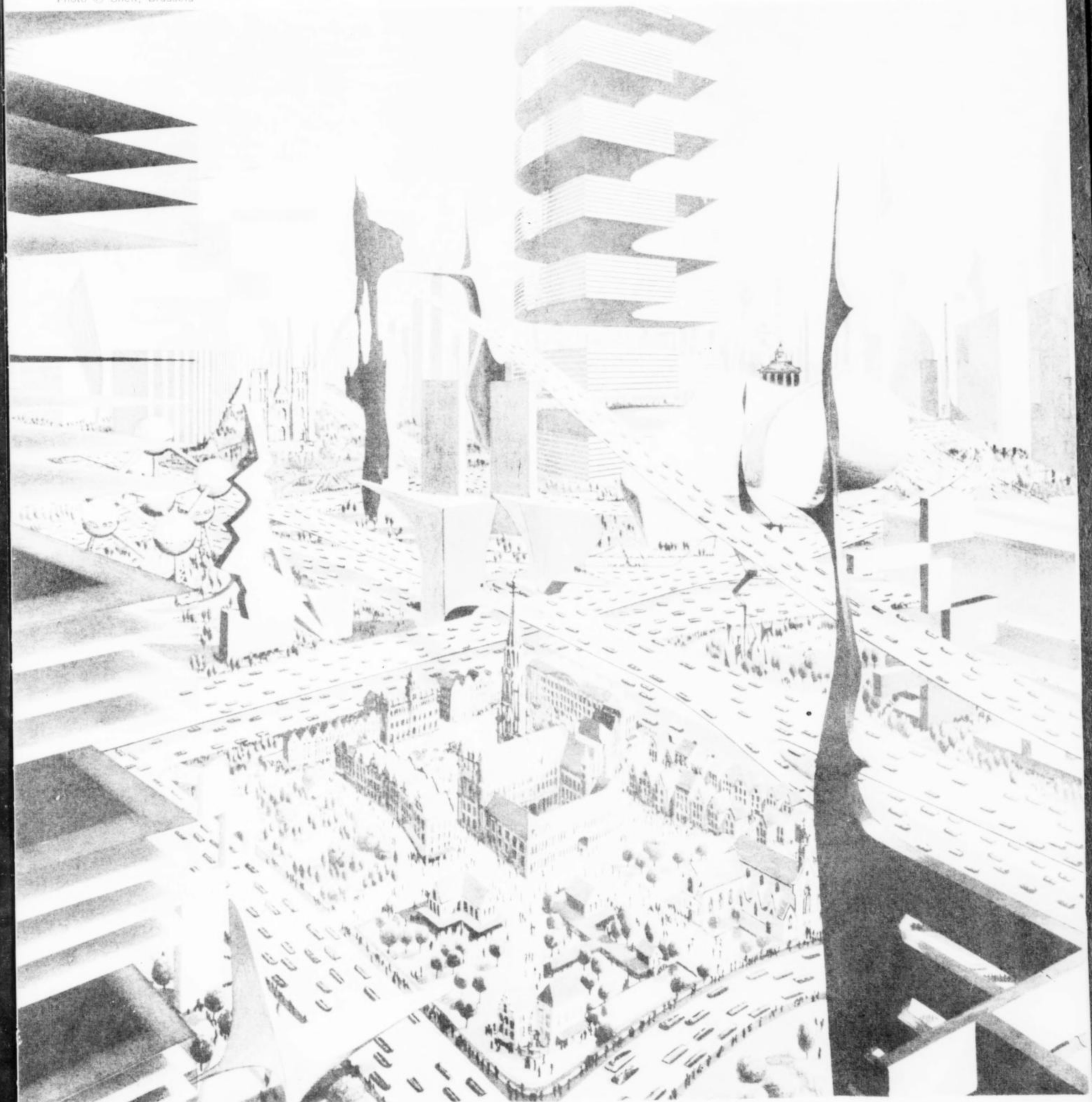
Whenever and wherever man can benefit from heat and electricity, nuclear energy in its many forms can help bring about a better world. Several other nuclear uses of the future deserve at least a brief mention.

CONTINUED ON PAGE 44

GLENN T. SEABORG, *chairman of the U.S. Atomic Energy Commission, and Nobel Prize Winner in chemistry (1951, with E.M. McMillan) has a distinguished record in nuclear chemistry and leadership in scientific and educational affairs. He was co-discoverer of plutonium, of the isotopes plutonium-239, uranium-233, neptunium-237; and of the elements 94 (americium), 96 (curium), 97 (berkelium), 98 (californium), 99 (einsteinium), 100 (fermium), 101 (mendelevium), and element 102. Dr. Seaborg and his colleagues have also identified over 100 isotopes of elements throughout the Periodic Table. He is the author of some 200 scientific papers, and was a member of the U.S. delegation to Moscow for the signing of the 1964 Test-Ban Treaty.*

Brussels in the 25th century as visualized by a 20th-century artist. In the city centre is a "Sacred Isle," on which have been preserved the central square, the "Grande Place" with its great Town Hall and other historic buildings. The drawing is taken from a calendar foreseeing the world of tomorrow, published in Belgium in 1962 by the Shell Petroleum Company.

Photo © Shell, Brussels



Far beyond our wildest imagination

Nuclear power could be coupled with tube-well pumps to tap the vast water resources which lie deep underground in many arid areas and which are being identified by the United Nations Hydrological Decade studies.

Radioisotopes will power batteries in weather, navigation and communications satellites. And they may even serve as power supplies for surgically implanted artificial hearts.

Before the end of the century, nuclear reactors no larger than a small car will be used to propel space craft for manned missions to Mars. Life support systems for space travel will be nuclear powered and some day nuclear reactors may help man create a habitable environment for a future moon colony.

In the future, it may be primarily nuclear energy and its associated technologies that allow man to explore and exploit the ocean.

Nuclear-powered deep sea research vessels are already being developed. By the 21st century, man may be harvesting food from the sea, mining its mineral resources, perhaps even living for extended periods deep beneath the surface.

If present development programmes are successful, engineering with nuclear explosives could help to release deeply contained gas and ore reserves and create underground reservoirs to hold rainfall in regions where rapid surface evaporation takes place.

Peaceful nuclear explosives might also be used to build a canal, a new harbour or cut through a mountain barrier (see article page 14).

Because nuclear fuel is compact and long-lived, the atom's benefits are less tied to any accident of geography which gives one country fuel while denying it to another.

Once a nuclear power station is built it can be used economically as readily in the desert as in an industrial centre. In fact, as I indicated earlier, it could turn the desert into an industrial centre.

Since real economies in nuclear reactors are most often in large size plants, the future may see several nations joining together, in co-operation with the advanced nations and the International Atomic Energy Agency, to share large nuclear generating plants as they now share research machinery in centres such as the European Organization for Nuclear Research (CERN) in Geneva, which Unesco helped create.

This drawing together of men from many nations to work together and to share scientific knowledge and technological benefits can be a very important spin-off of nuclear energy.

It would be naive of me to ignore how nuclear energy was introduced to the world. I have not forgotten, nor should my optimism on the power of the peaceful atom be taken to indicate that I am not realistic about the ever present question of nuclear annihilation. I have lived very close to this question for more than 20 years.

But I have also seen the birth of nuclear power to light homes and run factories, to drive ships across the ocean, to power satellites in orbit. I have seen the atom used to study life, to help create knowledge, to improve agriculture, to save lives and to make living more understandable and more enjoyable.

There is a cosmic 'glue' that binds the nucleus of the atom. It is a force stronger than any other force found in nature. As that cosmic force is released to the probing of man, and as we put it to work for man, perhaps another force will come into existence —one that will bind men together in a universal way, matching our human will with the physical powers we have learned to wield.

If this comes to pass, we may expect quite a future, and I think it might well be one far beyond that which you or I could dare to imagine today.

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ISOTOPES IN 'KID GLOVES' *(Continued from page 18)*

Some of them may have to be contained and isolated for perhaps hundreds of years.

This may sound formidable, but there are ways of reducing their volume for safe storage and new ways are continually being found of turning a number of the elements in them to good use. Some of their constituents are in fact placed in machines used for medical work, for processes linked with agriculture and for some industrial work. There is no doubt that more and more uses will be found to relieve the burden of storage. There are some scientists who claim that the by-products to be found in the waste can become the most valuable boon to man from atomic energy.

So far, I have been dealing mainly with ways of obtaining power from the atom to create electricity because abundant and cheap power will provide one of the most significant ways of improving living standards and reducing tension between nations. There are, however, many other ways in which discoveries and techniques arising from nuclear energy are being applied for the well-being of the world.

Radioactive materials and devices linked with them have brought about notable advances in medical research and treatment, are assisting in conserving and increasing food supplies, are helping to improve industrial efficiency, and are contributing to progress in many branches of science.

This means that in many walks of life workers are handling such materials daily and that many more will do so in the future. The fact that this can happen without adding considerably to the risks of life is due to the immense amount of research undertaken before any project is started and to the intensive restrictions imposed by governments and all the authorities working under them.

Sometimes this super caution is irksome to nuclear specialists, who feel that they have to overcome bigger obstacles than those engaged in other industries. There is no doubt that the development of many promising ideas is slowed down for this very reason. Nevertheless, the caution demonstrated has had its effect in proving that the safety both of populations and of individuals overrides all other considerations.

It is for this reason that confidence will grow and that atomic energy will steadily expand its role of contributing to the peace, health and prosperity desired by the peoples of the world.

The nations harness the atom

Nuclear power on the high seas

Italy, the Federal Republic of Germany and Japan are joining the U.S.A. and the U.S.S.R. as nuclear shipbuilders. The National Nuclear Energy Commission of Italy and the Italian Navy are building an 18,000 ton merchant vessel equipped with an 80 MW experimental reactor. At Kiel, the German bulk carrier, "Otto Hahn" will soon have its advanced pressure-water reactor installed, and Japan's first nuclear ship is now being designed. The Japanese expect that in the next decade, 30-knot nuclear-powered "container" ships and 500,000 ton nuclear-powered tankers will be competitive with conventional ships.

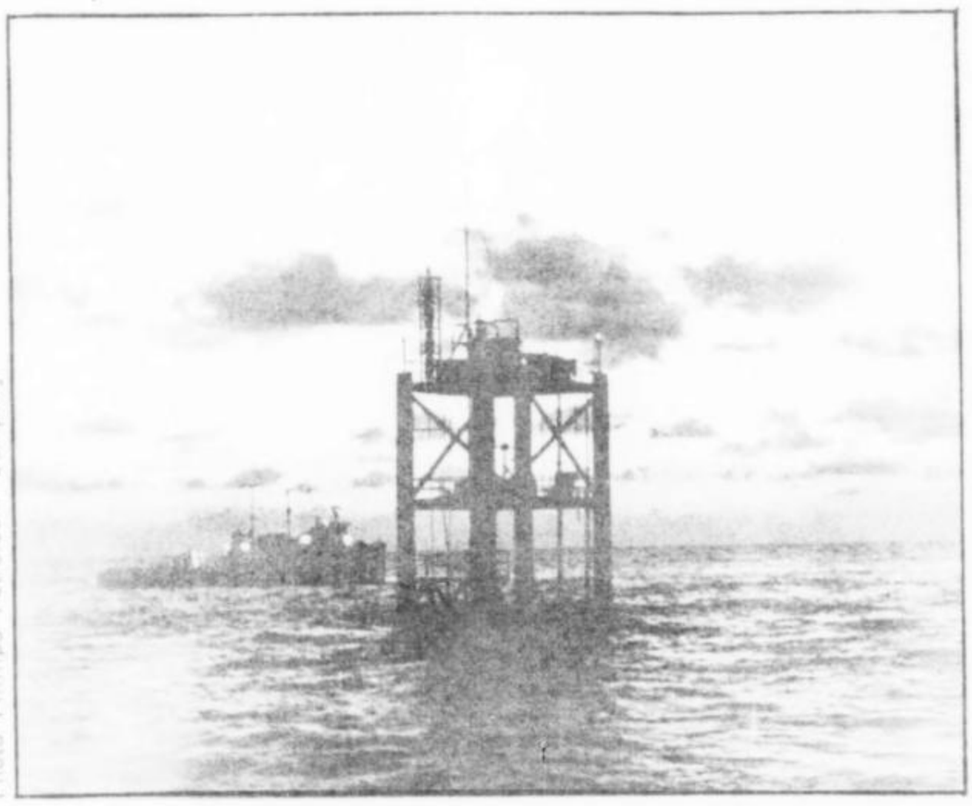


Photo Phillips Petroleum Company

Navigational warning devices—flashing light beacons and foghorn—on this oil and gas drilling rig in the Gulf of Mexico are powered by electricity from a nuclear generator installed 40 feet below the water line. Inherent reliability of the radioactive heat source (in this case strontium titanate atoms) and absence of moving parts to convert heat to electricity makes the system almost foolproof.

The cup that cheers

The "tracer technique" (when radioisotopes, emitting detectable radiation, are followed through a process) has helped improve Soviet beer production. Brewers have found the lifetime of latic acid bacteria which has allowed them to reduce the fermentation process from five or six days to one and a half days. The beer's quality has also been improved. Different results in British research into whisky may be bad news for illegal manufacturers. New techniques can establish a dating method for certains spirits and can be used to detect illicit stills. Radioactive carbon in the atmosphere, as a result of its movement through barley into whisky, can also be measured.

Dating by nuclear tracks

The age of minerals can be found from marks made on crystals by the natural fission of uranium and thorium isotopes. Now scientists have found other tracks, made as a result of normal decay of the elements, which lead to much greater dating accuracy. In normal decay, an atom ejects an alpha particle. After throwing out the alpha particle, the nucleus recoils like a gun firing a shot, and the recoil atom also makes marks (known as nuclear tracks). This discovery seems to have improved dating methods by about three thousand times.

Nuclear medicine in New Zealand

New Zealand appears to have the highest density, in relation to population, of therapeutic nuclear medical facilities in the world.

Needles explore for oil

One way of finding oil-bearing geologic formations is to lower radioactive needles into the ground or into test wells and measure the changes in their radiation as they pass through various types of rock. A geologist records the amount of radiation at several places and draws a "profile" of the underlying layers of earth. This profile tells him if drilling would be justified.

Radioisotopes vs. malaria

The Arab countries, in their fight to control mosquito vectors of malaria, are using radioisotope tracing to check the flight range, longevity and mortality of mosquitos. The same technique has been used to study other harmful pests, like grasshoppers (see article, page 18).

Engine wear and friction

Using radioisotope tracers, Soviet scientists have studied how dust contributes to wearing out tractor engines. Studies show that dust particles whose average diameter is 10-20 millionths of a centimetre cause most wear.

Unesco Courier—atom-inspected?

The Unesco Courier—like most paper products—was probably atom inspected. For several years, isotope gauges have been used to "feel" the thickness of paper while it is rolled out by machines at high speed. As the paper passes between a radioisotope source and a thickness-gauge

CONTINUED ON NEXT PAGE

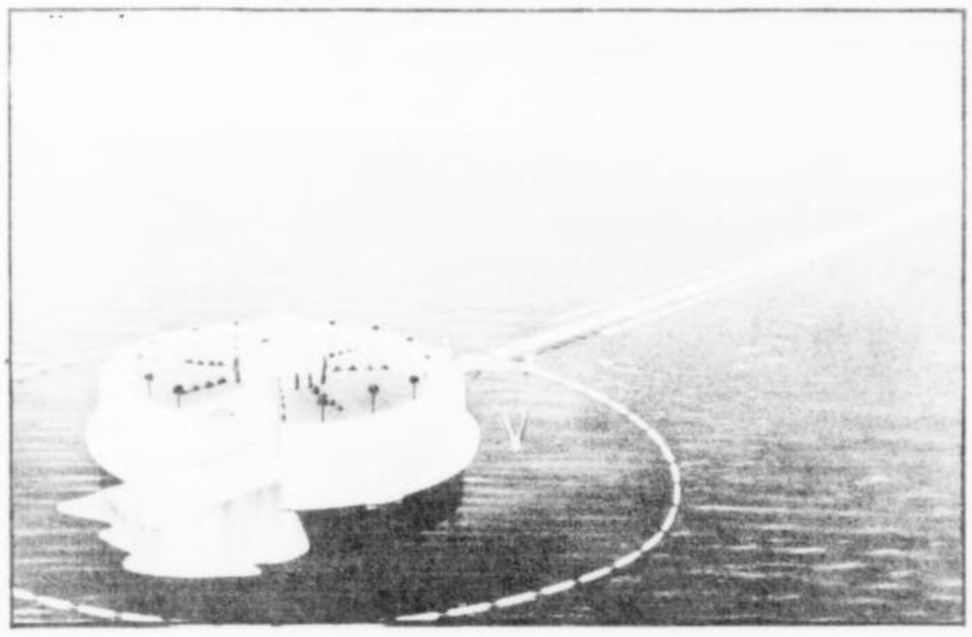


Photo Oak Ridge National Laboratory, U.S.A.

A nuclear powered sea water conversion plant capable of producing one thousand million gallons of fresh water per day and the electric power needs of a city of 5 million people might resemble this artist's conception. It would be operated by three natural uranium reactors and nine turbogenerators.

detector, the amount of radiation reaching the detector varies according to the thickness and density of the paper that separates it from the radiation source.

Nuclear-powered Northern Lights

Most of Sweden's additional power production in the 1970s and 1980s will come from nuclear plants. Nuclear power production is expected to increase over seven-fold between 1975 and 1985: by the late 1970s, at least one new nuclear-powered unit will be added to the Swedish power grid annually. In addition, combined production of heat and electricity, based on nuclear power, may be carried out in some major cities.

Isotopes on Mars

Radioisotopic tracers may help to find life on Mars. The American Project Gulliver's space scientists propose an unmanned device that will land on Mars, shoot out a string covered with silicone grease, and then pull it back. The retrieved string, covered with Martian soil, will be soaked in a culture broth containing radioactive carbon. If bacterial life is present in the soil, radioactive carbon dioxide gas will be given off and automatically measured by a radiation counter. From the counting rate sent to Earth by radio, scientists will be able to tell whether there is life on Mars and, if so, something about the kind of life.

Improved wood

Wood may be made harder and therefore more useful by soaking it in a simple chemical and irradiating the soaked piece so that the chemical molecules combine between the wood fibres to make a plastic. The beauty of the wood is unchanged.

Radioactive beads slow down cancer

Cancer is the runaway growth of cells. The secretions of the pituitary gland stimulate cell reproduction so surgeons sometimes remove the gland to slow down growth of a tumour. Now, tiny yttrium-90 oxide beads, glasslike in nature, can be implanted directly in the gland with much less difficulty and risk. The beads destroy the gland with little damage to its surroundings because yttrium-90 emits beta rays whose penetrating power is limited to the immediate area of the implant.

Gamma beam weight machine

In the U.S.S.R., a device has been perfected that measures the weight of a heavy mass without coming into contact with it. Operating on the principle that the ability of material to absorb gamma rays depends on its density and thickness, such devices have been used to determine the weight of a loaded, moving train. A gamma source (cobalt-60) is placed under the railway track and a scintillation counter above. The gamma beam passing between source and counter diminishes in intensity, as the train passes through it, in relation to the weight of the train's load. The readings are taken and converted automatically into units of weight.

Labelling oil

Oil is commonly shipped long distances through pipelines. Several companies often use the same pipeline, just as ranchers used the same range for their herds. As ranchers brand their cattle, oilmen use radioisotopes to mark different oil batches. For example, some of the isotopes precede company A's oil, and another tracer is carried ahead of company B's shipment. A radiation monitor detects the radioisotopes at the distribution point with the result that A's oil is routed into tank A and B's products into tank B.

Radioactive dirt improves soap

Soap and detergent manufacturers want to know how effectively their products remove dirt from soiled clothes. Some manufacturers test new soaps by using them to wash radioactive "dirt" from clothes; the resultant dirty water is examined with instruments to measure the number of radioisotopes that have been removed.

The roots of this bean plant have been injected with 25 millionths of a gramme of a radioisotope to find out how a plant feeds itself and grows. Photo left, taken by placing a film in contact with the plant, shows how radioactive material has been taken up to the leaves. Such experiments also tell botanists how best use can be made of fertilizers.

Photo USIS

Fresh water through atomic power

A U.N. survey states that about 20 water-short areas in the world need desalting plants, and 41 others may soon need them. Nuclear power is already playing an important part in alleviating this problem. The first Soviet nuclear power station capable of desalinating 120,000 cubic metres of sea water a day is under construction at Shevchenko on the Caspian Sea; the United States is planning a large electricity-desalination plant near Los Angeles (see article, page 42) the United Arab Republic is interested in installing a nuclear power-desalination plant near the Mediterranean; Israel is studying the possibilities of a plant to produce 100 million gallons of water a day and 200 MV of electricity.

Atomic detective

It is possible that Napoleon's death was due to arsenic. After neutron irradiation analysis of a hair from the French Emperor's head, scientists have concluded that he had been given arsenic in large quantities. Neutron irradiation of the hair changed some of its atoms to radioactive isotopes in which elements of arsenic were found.

CONTINUED ON PAGE 48

by
René Maheu
Director-General
of Unesco

'UNESCO SHOULD BECOME THE ORGANIZATION FOR YOUTH'

A poignant appeal that the problems of youth cannot be ignored in the world today, was made on June 24 by René Maheu, Director-General of Unesco, in a special address to Unesco's European National Commissions gathered at a regional conference in Monaco. "Unesco should become the organization for youth," Mr. Maheu declared, "where young people can put their questions freely—all their questions—within the framework of the world perspective." We publish below all the passages from this address which bear on youth.

FOR several years now, the flood-tide of youth has risen irresistibly, and youth has won an increasingly important position in society. Youth represents more than one-third of the total world population—in some countries nearly half the population—and the role of young people is mounting because of the increasing call made upon them by our technological civilization with its steady demand for adaptation and inventiveness. Yet the gulf separating young people from adults seems to be growing bigger every day.

Adults were at first surprised, sometimes amused, and often shocked, by the tendencies of some young people to escapist or even withdrawal behaviour, as manifested in the vogue for certain types of songs, fashions in clothes and hairstyles, sexual freedom and, more seriously, the taking of drugs.

Just as they were beginning to resign themselves to these "differences", adults have again been caught off guard—this time by the revolts which have struck the most venerable institutions of society and the strongest of governments. And the ultimate paradox is that these revolts have been sparked by university students who, one would have thought, had the strongest reasons to be satisfied with the established order, since the most promising careers lay ahead of them.

This revolt is sweeping across virtually every part of the world, but it is particularly striking in Europe where, in many countries, it has taken on the form of an open dispute, not only with the university but with society as a whole.

The situation is very grave. A society rejected by youth is by definition a society without a future, and therefore condemned, regardless of the force of authority or constraint that may temporarily be brought to bear on the protests and aspirations of youth, by the pride, fears and the interests of adults already established in life. In my view, we are now witnessing the rejection of a certain type of society, or indeed a certain type of civilization.

It is not, as is often said, just a matter of giving youth an ideal. For the most part, young people already have their own ideal. Even if it is confused and often expressed in a naïve way, this ideal is eminently worthy: it consists of an idea—a dream if you will—of human relations without violence and without deception.

In contrast to this ideal, the kind of society we are preparing to bequeath to them fills them with horror on many counts (even if it can satisfy their immediate wishes as no previous society has) because it profoundly shocks their demands for justice and peace. To them it seems to be the adults who are lacking in ideals.

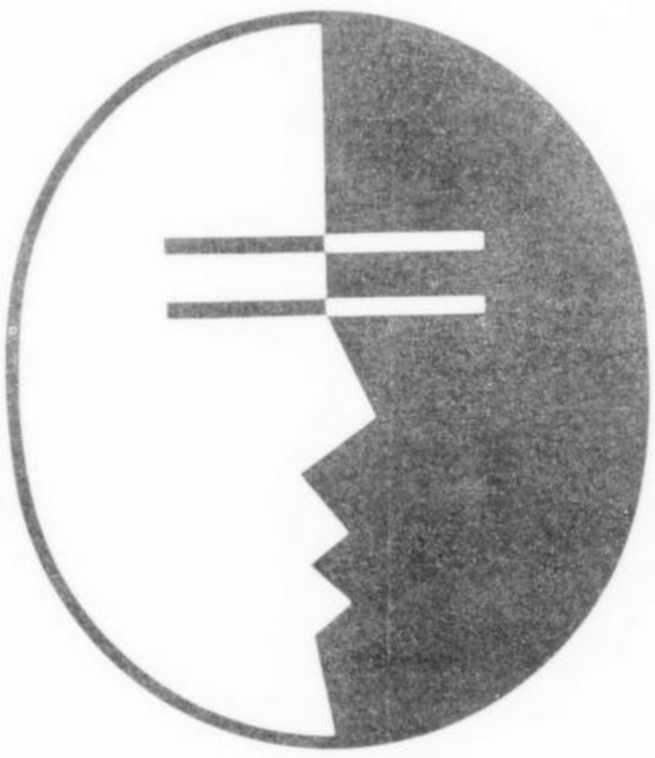
I believe that this situation confronts Unesco with a major duty and a unique opportunity to carry out, with new vigour and on a wider scale, the ethical activities which make up its essential role. In this year, 1968, Unesco must approach young people as ten years ago it approached the less-developed world, with the same openness of heart and mind. By this I don't mean the strengthening of just those activities in Unesco's programme of direct interest to youth. What I have in mind is a total change in the whole orientation of Unesco, affecting the nature and activities and the methods of our organization.

I recall the fundamental change that took place in Unesco ten years ago with the mass entry into the organization of the developing countries, which had just acceded to independence.

Whereas Unesco's work had until then been almost exclusively concerned with promoting intellectual co-operation between developed countries, almost overnight, it was converted into a field operation organization for helping the under-privileged nations of the world. These countries quickly found in Unesco a true understanding and a dynamic, positive friendship that has continued with unfailing vigour. For their part, the developing countries have shown full confidence in Unesco, and that confidence has likewise never wavered, and gave Unesco a new humanistic dimension as well as accrued possibilities of action.

A similar change in our thinking and structure is needed today—this time, deeper and more radical than before. Unesco should become the organization for youth, the organization where young people should be able to put their questions freely—all their questions—in the worldwide perspective; where they can give form to their dreams by seeking their contribution to human co-operation and where they can bring to bear all their fervour and the limitless fountain of their skills and ideas on behalf of disinterested action for peace.

This is my fervent wish, and the appeal I make today, with my mind assailed by anxiety but my heart filled with hope.



SYMBOL OF INTERNATIONAL YEAR FOR HUMAN RIGHTS

The design above is the work of Victor Vasarely and was commissioned by the International Association of Art to commemorate the current International Year for Human Rights. It has been officially adopted by the Association (an organization created and supported by Unesco) and its member organizations in 57 countries. The International Association of Art has called on artists everywhere to support world efforts to give force to the principles adopted 20 years ago in the Universal Declaration of Human Rights.

Better crops through radiation

In 1967, the IAEA and FAO were testing wheat mutants in 12 countries and started studies in Africa and Latin America to increase the resistance of wheat to diseases. A mutant rice, produced by radiation is being put on sale in Japan. It has a larger yield, a stronger straw and a better response to fertilizers than existing varieties. In North Africa and the Middle East, mutant wheats produced by radiation give higher yields than local or common varieties. In the Soviet Union, radiation has increased cabbage crops by 5 to 10 per cent, cucumbers by 15 to 30 per cent, tomatoes by 10 to 15 per cent, carrots by 25 to 30 per cent and radishes by 6 to 11 per cent.

Krypton against smog

Krypton, a radioactive form of inert gas, has been pressed into service in the battle against smog. In one type of smog alarm, krypton is "caged" in a crystalline chemical. When sulphur dioxide, a notorious air pollutant, enters the alarm device, krypton is released through chemical action. It is then scanned by a Geiger counter and the number of radioactive disintegrations recorded show how much sulphur dioxyde air pollutant displaced the krypton.

Latin America—peaceful progress

All atomic work in Latin America is devoted to peaceful uses, much of it in direct collaboration with the International Atomic Energy Agency. Argentina, Brazil, Colombia and Venezuela are operating, and Mexico and Uruguay are constructing, research reactors; Brazil is working to improve rice and Argentina is using nuclear radiation in wheat experiments—both studies linked with FAO/IAEA programmes; Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama are working with the IAEA and FAO to eradicate the Mediterranean fruit fly; Mexico, Venezuela, Argentina and Brazil have set up radioisotope production centres; Guatemala is developing industrial gamma radiography; a radiological protection service has been started in Chile; Cuba is establishing a film badge and dosimetry service for hospitals; investigations of ground water resources are being made in Chile, Brazil, Uruguay and Ecuador; Mexico and U.S.A. are examining a nuclear power-desalination project to serve parts of both countries.

British nuclear electricity

Nuclear power stations in Britain will be able to generate some 15 per cent of the country's electricity when the Oldbury station becomes operational later this year. Britain, a nuclear power plant pioneer, operated its first station at Calder Hall in 1956. In the next decade, it built 24 nuclear stations whose total capacity exceeded the combined output of all other nuclear plants in the world.

Earthquake barometer

Geophysicists at the Seismology Institute at Uzbek, Turkestan, have found a way to forecast earthquakes. Radioactive radon, one of the heaviest gases known, filters slowly and steadily upward from beneath the earth's crust, but its journey is suddenly accelerated if there are subterranean rock disturbances. Scientists have measured the radon content of the water in an artesian well, 2,000 metres deep, and when it changed, they could foresee local earthquakes 15 to 20 hours in advance and get an idea of their severity.

A SCIENCE OF PEACE FOR THE ATOMIC AGE

"We can make better and better preparations for war, our technical progress having given birth to titanic weapons, but we cannot prepare for peace any better now than in the age of bows and arrows." These words of Professor Gaston Bouthoul, of the French Institute of Polemology, state with sharp clarity why a science of peace is urgently needed today when the warlike uses of the atom could destroy civilization.

This science of peace, Peace Research, exists and is being carried on in many countries of the world. It is still very young, still somewhat unformed, still woefully undermanned and underfunded by comparison with the world's expenditures of thousands of millions of dollars annually on arms research and with the fact that 18 per cent of all the scientists who ever lived are today at work on arms research[1]. It is nonetheless a rapidly growing field of study, a glint of hope for the future establishment of a stable and permanent peace.

The latest number of *Impact of Science on Society*, Unesco's quarterly which examines the social consequences of science, is devoted in full to the theme The Scientific Basis of Peace.

This *Impact* number brings out why Peace Research is so fundamental: because treating war and peace as purely political matters, as is generally done, has resulted in but limited success in containing wars. Any small war could be the accidental trigger for nuclear war, because statesmen and diplomats, the engineers of peace, who strive to preserve the present fragile structure of peace and eventually to erect a strong structure, have less basic sound knowledge available to them about the factors involved in war and peace than have engineers who design buildings and highways.

In the keynote article, "Peace Research, the Science of Survival", Professor Bert V.A. Röling, of the University of Groningen, Netherlands, broadly describes this vitally important young science and the vast array of subjects it studies: man himself, the role of the press and of prejudice, national societies, the international system and the structure of a stable peace, among a whole host of others.

"Why Is Man Aggressive?" is discussed in a round-table article by seven British biological and social scientists and Professor Bouthoul. Is man aggressive by nature? Most of the Round Table participants say "yes". Mr. Philip Noel-Baker, Nobel Peace Prize 1959, says "no". Other factors that exacerbate aggressiveness—such as overpopulation, the use of language, social deprivation—are discussed and parallels are made with behaviour in animal societies.

In still other articles, Professor Kenneth E. Boulding, of the University of Colorado, proposes a "Data-Collecting Network for the Sociosphere", to provide accurate information about the world social, economic and political climate to national leaders to minimize the miscalculations that can lead to war; Professor Bouthoul, "Polemology and the Solution of Conflicts", discusses the scientific objective study of war (in Greek, "polemos"); Professor Anatol Rapoport, of the University of Michigan, shows how "The Application of Game Theory to Peace Research", by dispassionately and logically showing how war is always an "unprofitable" activity, in terms of gains and losses, can eventually help undermine the present legitimacy of war as an instrument of national policy; and Professor Ignacy Sachs, of the Peace Research Committee of the Polish Academy of Sciences, examines "Ethnocentrism—Source and Aggravating Factor of Conflicts".

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(1) This statement is based on the knowledge that 90 per cent of all scientists who ever lived are alive today, and of these, 20 per cent are at work on arms research — Editor's note.

FROM THE UNESCO NEWSROOM...

Europe's poisoned rivers

Europe's lakes and rivers are being increasingly polluted by dumping of sewage, detergents, pesticides, metals, phenols, ammonia, and other chemical and industrial wastes, reports FAO. Loss of oxygen from man-made and natural causes and "ageing" of lakes and ponds through silting and plant invasion are contributing factors. A symposium on how these problems affect European fisheries will be organized in 1970 by FAO's European Inland Fisheries Advisory Commission.

Food coins

A series of coins supporting the work of FAO are being issued this year by over 20 countries. This is the first time that a group of nations have used their coinage as an educational means for raising agricultural production. India, Nepal, Uganda and the Republic of Vietnam plan to issue coins on October 16, the 23rd anniversary of FAO's foundation. FAO will sell special sets of the coins and devote proceeds to regional projects for farm credit.

"THE NUCLEAR CHALLENGE" an IAEA film

A 40-minute colour film showing the increasing use and effects of peaceful atomic energy, and the International Atomic Energy Agency's role in promoting its worldwide development, has been available since last year in English, French, Spanish and Russian versions. The film was produced by the International Atomic Energy Agency with Kratky Film, Prague (Czechoslovakia). The English version is narrated by Peter Ustinov. Special attention is focussed on work in agriculture, medicine, industry, hydrology, research and the immense possibilities of nuclear power systems. The film (16 mm) costs $150.00 U.S. (or equivalent). For further information write: Division of Public Information, International Atomic Energy Agency, Kärntnerring 11, A-1010, Vienna, Austria.

In one piece again

Three very different works of art which had one thing in common were recently exhibited at Unesco. They had all previously been dismembered. Now, through the co-operation of different museums, they have been reconstituted and can be seen by the public as they were originally conceived by their authors. A unique 16th-century carpet was cut in two in Poland to fit the altar steps in Cracow Cathedral, and the unused part sold in Paris. One half belongs to the Museum of the Royal Castle of Wawel in Cracow, the other, to the Museum of Decorative Arts in Paris. A 14th-century polyptych by Paolo Veneziano was dismembered in 1863, but was reconstituted by the Louvre in 1956 from panels in the Ajaccio and Toulouse museums. One half of the pen and ink drawing, "The Battle of Bergen" by Willem van de Velde the elder, was acquired by the Greenwich Museum (U.K.), which in 1958 presented it to the owner of the other half, the Rijksmuseum in Amsterdam.

More meat on the menu

A sharp rise in meat eating has been noted in many countries. The U.S.S.R. increased its meat production and consumption by about 95 per cent in the 1950s and early 1960s, reports FAO. Meat eating in Eastern Europe rose by 65 per cent, in Western Europe by 84 per cent and in North America by 44 per cent. But meat consumption per person in the developing countries has not improved because production can hardly keep pace with population growth.

Water, water everywhere...

Canada recently marked its participation in the International Hydrological Decade by issuing a five-cent commemorative stamp. Canada has about one-seventh of the world's fresh water in her lakes and one-tenth in her rivers, but fully one-half flows north and is not available to 90 per cent of the population. Over 97 countries have joined in the Hydrological Decade, a programme co-ordinated by Unesco to study the world's water resources and their management.

U.A.R. centre for exchange of publications

The United Arab Republic, recently inaugurated a Centre for the Exchange of Publications. The Centre, at 27 Abdel Kalek Sarwat St. Cairo, is supervised by the National Library (U.A.R. Ministry of Culture).

Flashes...

■ *A carving of a man's head, found recently in Afghanistan, is the oldest known sculpture in Asia. It has been radiocarbon-dated at 20,000 B.C.*

■ *The first U.N. Conference on the Exploration and Peaceful Uses of Outer Space is being held in Vienna from August 14 to 27.*

■ *WHO, has so far tested 1,249 new insecticides in its continuing fight against insect-borne diseases.*

■ *An "early-warning" system to speed up action to meet food shortages is being set up by FAO and the World Food Programme.*

■ *46 new radio stations are being opened in Spain this year.*

BOOKSHELF

■ **The Frail Ocean**
By Wesley Marx
Cowan-McCann, Inc., New York, 1967 ($5.95)

■ **The Cosmos of Arthur Holly Compton**
Edited by Marjorie Johnston with an introduction by Vannevar Bush
Knopf, New York, 1968 ($10.00)
The story of a man who devoted his life to the advancement of science and education and the cause of world peace

■ **Men and Medicine in the Middle East**
Written and compiled by Jan Simon
The WHO Regional Office for the Eastern Mediterranean, P.O. Box 1517, Alexandria, U.A.R. 1968

■ **The Emergence of the Eastern World (Seven Essays on Political Ideas)**
By G.L. Seidler, with a forward by Sir Isiah Berlin
Pergamon Press Ltd., Oxford, U.K., 1968 (80/-)

■ **Scientific Research in Israel**
National Council for Research and Development; Center of Scientific & Technological Information, Tel Aviv, 1968.

■ **Wyatt to Marvell**
(The Argo Book of Recorded Verse, Vol. 2)
General Editor George Rylands
Oxford University Press, London, 1967 (hardback: 21/-; paperback 13/6).

■ **In Latin American Lands**
(Heath Social Studies Series)
By Ralph C. Preston and John Tottle, D.C. Heath and Co., Boston U.S.A.

■ **Captain James Cook**
By Alan Villiers
Scribners, New York, 1967 ($7.50)

★

■ **Natural Resources and International Development**
Marion Clawson, editor
1966 ($2.00)

■ **Civilian Nuclear Power (Economic Issues and Policy Formation)**
By Philip Mullenbach
1966 ($2.00)

■ **Equality in Political Philosophy**
By Sanford A. Lakoff
1966 ($1.75)

■ **The Social Responsibility of the Press**
By Edward Gerald
1966 ($1.50)

■ **Strategy for Mobility (Transportation for the Developing Countries)**
By Wilfred Owen
1966 ($1.75)

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Letters to the Editor

WORLD CHARTER ON HUMAN RIGHTS

Sir,

After reading your remarkable issue on International Year for Human Rights (January 1968), I would like to know: 1) Which nations approved and adopted the Universal Declaration of Human Rights? 2) Which nations abstained? 3) Which nations, having adopted the Declaration, also apply it in practice?

C.J. Grandin
Saint-Martin-de-la-Place, France

48 nations voted in favour of the Universal Declaration: Burma, Canada, Chile, Republic of China, Colombia, Costa Rica, Cuba, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, France, Greece, Guatemala, Haiti, Iceland, India, Iran, Iraq, Lebanon, Liberia, Luxembourg, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Thailand, Sweden, Syria, Turkey, U.K., U.S.A., Uruguay, Venezuela, Afghanistan, Argentina, Australia, Belgium, Bolivia, Brazil.

Eight nations abstained : Byelorussian S.S.R., Czechoslovakia, Poland, Saudi Arabia, Ukrainian S.S.R., Union of South Africa, U.S.S.R., Yugoslavia.

Two nations were absent: Honduras and Yemen.

As our January 1968 issue on Human Rights pointed out, no country can pride itself on having completely fulfilled all the Articles of the Declaration — Editor.

WHAT WAR MEANS TODAY

Sir,

Bravo for publishing "The World We Hope For", Maria Cristina Costa Diaz's prize-winning essay (Feb. 1968), and congratulations on all your issues, notably those on Apartheid, nuclear perils and the present arms race. All countries, particularly the industrially-developed, would do well to devote a few hours of their radio and television every month to programmes that bring home the meaning of nuclear warfare. And why not set up a special fund administered by Unesco to provide a free, world-wide distribution of booklets on the terrible dangers of atomic conflict. An immense effort will be needed to shake people from their present apathy.

C. Bonnafoux
Maisons-Alfort, France

'SUBJECTIVE' ARTS 'OBJECTIVE' SCIENCE

Sir,

In "Science and the Culture of our Times" by Lawrence Gould (Feb. 1968), which, at first sight, appears to be a useful modern commentary, there are a number of misleading statements which detract from its value and indicate confusion of thought on the subject.

Whilst not subscribing to the alleged dualism between facts and human values, I cannot agree that the postulates of faith in a religion and hypotheses and theories in science are analogous. The essence of a religion is belief in a supernatural being; only pure faith is required to appreciate this abstraction. In science, however, hypotheses and theories are but intermediate stages between the evaluation of factual observations and the application of this knowledge. To say that hypotheses are assumed as a matter of faith is to completely misunderstand scientific procedure.

Moreover, no thinking person can consider that exploration and understanding by the poet, or by any other type of artist, is similar to that of the scientist. The specific contribution of the artist lies in expressing his feelings about abstract things, in addition to describing his reaction to material things. In this work he embodies all this feeling, and poses many questions, but he never answers them. This is quite different from the work of the scientist.

Finally, the attempt to merge subjective opinions with objective observations is quite misleading. In the humanistic studies, mostly abstract values are being considered, and the statements concerned about them are largely those of preferences. In scientific work, however, the basis is that of measurement and the observation of processes. Obviously no experience can be impersonal, but the two disciplines under discussion are entirely different, and as the human brain finds it necessary to simplify knowledge by classification, the terms "subjective" and "objective" are quite acceptable.

N.P. Bridgewater
Abergavenny, Mon., U.K.

'WHITE' ACHIEVEMENTS IGNORED

Sir,

I shall not renew the subscription to your magazine which I took out for my daughter. In 1967 most of your issues were biased in many ways in favour of the developing countries, one example being that colonialism should be driven out or suppressed wherever it exists. The negative aspects of colonialism were dealt with, but the positive achievements of the "whites" in Africa and elsewhere were systematically disregarded. Many readers have already expressed their views on the issue dealing with South Africa and Apartheid. As I am opposed to the ideas it presented I have decided to terminate my subscription. In my view, articles of that kind, inspired by hatred and incomprehension, are not likely to promote the spread of international understanding.

Jean Jordan
Nice, France

POETRY OF LIGHT AND SHADOWS

Sir,

Long-standing readers of your magazine, we admired the Dec. 1967 issue on "Two Great Epics of Asia". We were particularly struck by the truly remarkable photographs of shadow theatre performances in Cambodia taken by Luc Ionesco.

Muriel Latscha
Paris, France

TWO GREAT EPICS OF ASIA

Sir,

Congratulations for your issue of December 1967 with its outstanding articles on the *Mahabharata* and the *Ramayana*, and on India and South East Asia, their history, traditions, art and peoples. It was indeed a window open on that vast region of the world. Why not do the same for Africa and America in future issues.

Francisco Ghisolfo A.
Viña del Mar, Chile

Sir,

Our faculty has a subscription to the "Unesco Courier" but the December 1967 issue was so excellent that I would like to order six copies. My class in Eastern Literature is now reading selections of the *Ramayana* and the *Mahabharata* and I would like these students to have access to several copies of the December issue.

Sister Marie Pierre
Marian College, Indianapolis, U.S.A.

THE COLOMBO PLAN

Sir,

The article on the Mekong River development project (Feb. 1968) describes the Colombo Plan as "The British Commonwealth's scheme for aiding its member countries in South-East Asia".

Although it true that the Colombo plan stems from British Commonwealth countries, the initial members being the United Kingdom, India, Pakistan, Ceylon, Australia, and New Zealand, it was soon expanded to include the United States, Afghanistan, Burma, Bhutan, Cambodia, Indonesia, Japan, the Republic of Korea, Laos, Malaysia, The Maldives, Nepal, North Borneo, the Philippines, Sarawak, Singapore, Thailand, and the Republic of Vietnam. The author himself has indicated that the Plan is wider than the British Commonwealth by referring to the aid given to one of the member countries—the Republic of Vietnam.

Bruce N. Kaye
Basel, Switzerland

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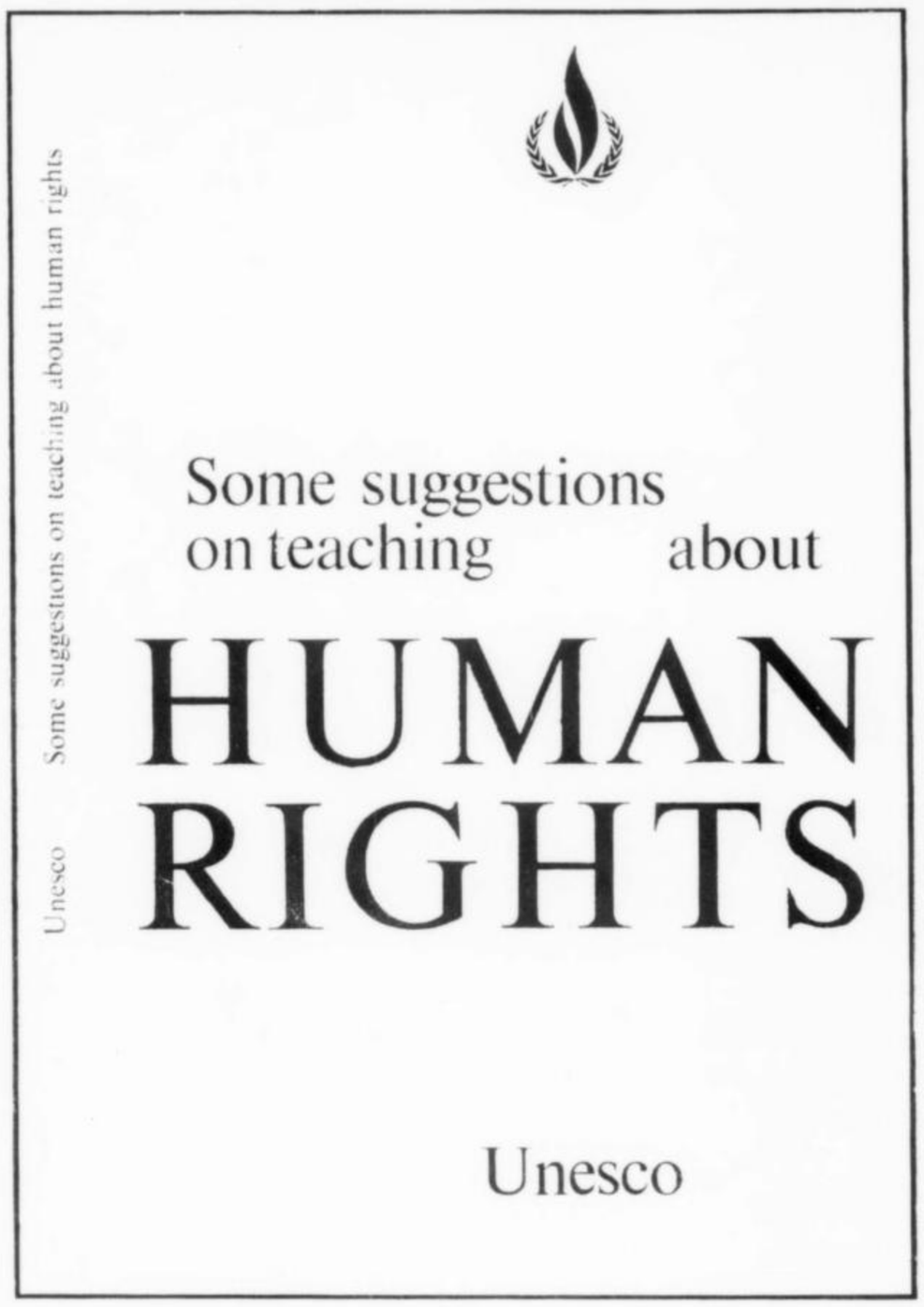

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■ Presents detailed accounts of projects carried out by schools or teacher training colleges as curricular or extra-curricular activities.

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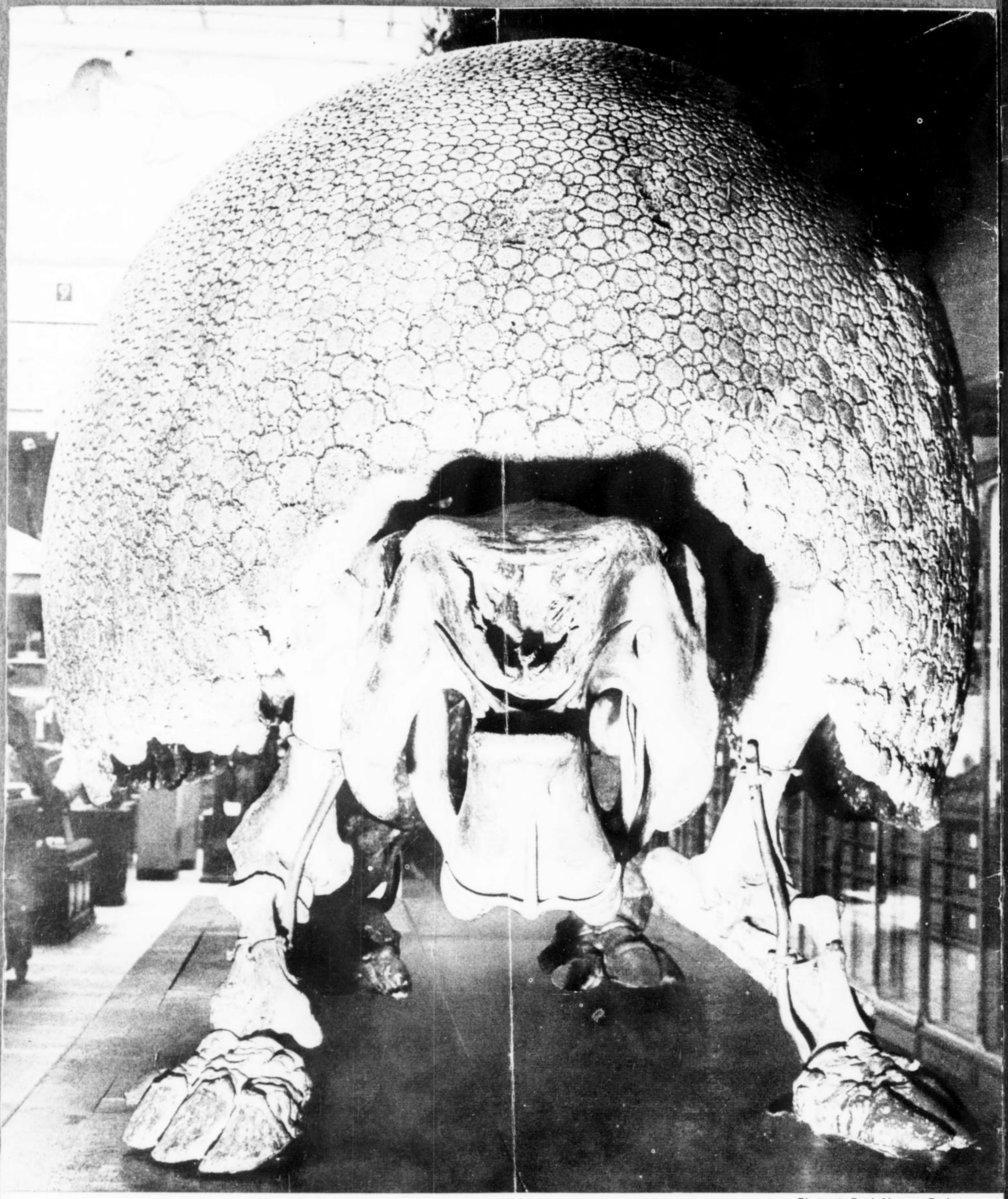

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NUCLEAR CLOCKS FOR DATING THE PAST

This prehistoric monster, 3 metres long, its back covered with a rigid carapace, is the glyptodon which became extinct during the last glacial period on earth, between 100,000 and 1,000,000 years ago. Resembling the present-day armadillo, of which they are a distant ancestor, glyptodons were to be found in many parts of the Americas. This one was dug up in Argentina. The recent development of techniques based on radioactive phenomena has provided science with a number of nuclear clocks for measuring geological time. Radioactive substances such as potassium-argon, rubidium-strontium and uranium are used to date rocks, minerals and human and animal fossil remains in geological strata (see page 26). A clock with a shorter life, the now famous carbon-14, has become the mainstay of archaeology and geology for studies of events up to 50,000 years ago. It also has wide applications in climatology, ecology and geography (see article page 22).